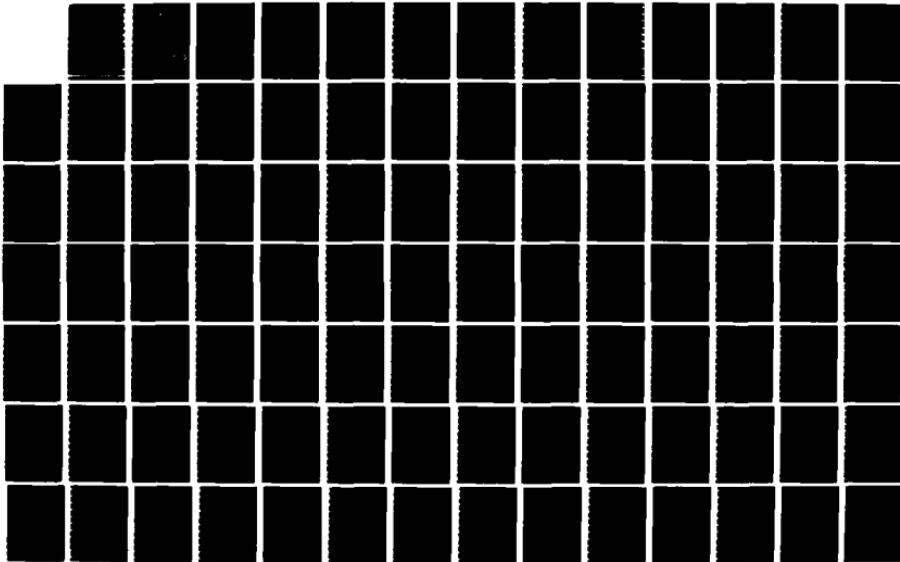
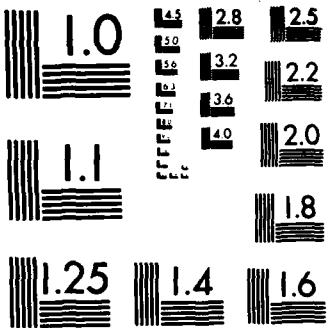


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A SLAM MODEL OF  
DOMESTIC AIRLINE PASSENGER FARES  
AND THE CONTRACT AIR SERVICE PROGRAM

THESIS

David A. Shepherd  
Captain, USAF  
GLM LSM  
AFIT/LSM/GLM/86S-72

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A SLAM MODEL OF DOMESTIC AIRLINE PASSENGER FARES  
AND THE CONTRACT AIR SERVICE PROGRAM

THESIS

Presented to the Faculty of the School of Systems and Logistics  
of the Air Force Institute of Technology  
Air University  
In Partial Fulfillment of the  
Requirements for the Degree of  
Master of Science in Logistics Management

David A. Shepherd, B.A.

Captain, USAF

September 1986

Approved for public release; distribution unlimited

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David A. Shepherd

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Abstract

This research develops a prototype simulation model to assist in evaluating the benefits of the Contract Air Service Program. This program provides special fares for government employees traveling on official business aboard certain scheduled domestic flights. Because deregulation of the airline industry has generated a profusion of discount fares, a model is needed to evaluate the contract fares against a cross section of fares rather than full coach fares alone, as has been done in the past.

Route selection for the model was based on passenger volumes and full coach fares. All combinations of passenger volumes and fares were represented in the initial selection of routes. Only routes with low total costs and, therefore, little impact on potential savings were discarded from further consideration.

Discount fares for each route were selected to represent the entire spectrum of restrictions. The scope of government travel characteristics required for the model were identified. Parameters were established to exercise the model's ability to apply discount fares for eligible travelers.

The results of the research prove the feasibility of implementing simulation as an improved means for evaluating the effectiveness of the Contract Air Service Program. Recommendations for the development of a comprehensive model are discussed.

A SLAM MODEL OF DOMESTIC AIRLINE PASSENGER FARES  
AND THE CONTRACT AIR SERVICE PROGRAM

I. Introduction

General Issue

The Military Traffic Management Command (MTMC) and the General Services Administration (GSA) claim they have saved \$200 million in government travel expenditures since the Contract Air Service Program was established with commercial airlines in 1980 (4; 5). This program provides special fares for government employees (military personnel and civilians of all departments and agencies) traveling on official business aboard certain scheduled domestic flights. In fiscal 1985, nearly 950,000 government passengers traveled on contract fares totaling \$82.6 million (4; 20; 21; 22).

The current impetus to cut government spending has precipitated a need to reevaluate all existing programs to see if they can be managed more efficiently. Savings cited in past MTMC reports on the Contract Air Service Program have been based on unrestricted coach fares (4; 20; 21; 22). However, major changes in the airline industry since deregulation have drastically affected the environment in which the Contract Air Service Program was conceived. Because deregulation has generated a profusion of discount air fares, regular coach fares may no longer be appropriate standards for measuring the effectiveness of the Contract Air Service Program.

### Specific Problem

Effective analysis of the Contract Air Service Program is hindered by the diversity and complexity of commercial airline fare structures. A model is needed which incorporates government travel characteristics and estimates the applicability of a cross section of passenger fares. Such a model will provide a more realistic indication of Contract Air Service Program benefits or identify if the program has outlived its usefulness.

### Research Objective

The objective of this research is to develop a prototype simulation model which can be used as an analytical tool to assist MTMC and GSA passenger traffic managers in making decisions concerning the Contract Air Service Program. The model is based on government travel characteristics and estimates the extent to which government travelers could qualify for restricted discount air fares. A comparison can then be drawn between travel expenditures incurred through the Contract Air Service Program and those that could be expected if the same transportation were procured on the competitive open market.

Information provided through this model can aid the program managers at MTMC and GSA in more effectively negotiating with participating carriers. By updating the government travel patterns and the commercial airline route and fare structure parameters of the model, the Contract Air Service Program can be reevaluated on a regular basis to ensure it continues to economically satisfy the government's air travel requirements.

Research Questions

1. What routes should be incorporated in the prototype simulation model? Over what routes should the Contract Air Service Program fares and other air fares be compared?
2. What discount fares should be modeled and what restrictions apply?
3. What government travel characteristics need to be included in the model?
4. If the Contract Air Service Program were discontinued, would the savings achieved by travelers using discount fares be negated by other travelers who would be charged full coach fare?

## II. Literature Review

### Introduction

The Airline Deregulation Act of 1978 has changed the airline industry far more drastically than most observers had expected (3:x1). It is difficult, however, to differentiate between how much of that change has been a direct result of deregulation and how much has been caused by other environmental factors, such as increasing fuel prices, recession in the economy with high inflation and interest rates, and the 1981 national air traffic controllers' strike and its aftermath (26:1; 28:178).

Perhaps the most visible change in the airline industry since deregulation has been that of domestic airline pricing strategies, particularly in passenger fare structures. In view of the current impetus to cut government spending, it is incumbent on Department of Defense (DOD) travel managers to have a firm understanding of these strategies in order to adopt policies which will ensure maximum benefits from our limited resources. An analysis of the Contract Air Service Program must include a review of how domestic airline pricing strategies have changed since deregulation and the effect current pricing practices have on Department of Defense travel management.

### Historical Background

Airline regulation began in 1916 and was initially directed toward compensating and controlling private aviation companies hauling air mail (29:105). The first regulation of passenger transportation by air was

really a condition of a second air mail regulation, the Kelly Act of 1925. This act authorized the United States Post Office Department to contract with private companies on a competitive-bid basis to carry mail by air, but it also required such carriers to provide facilities for transporting passengers (10:308). Aviation regulations from 1925 to the late 1930s continued to center on the airmail business, with passenger transportation taking a secondary role (15:206-207).

For several reasons, the financial condition of the industry had seriously deteriorated by the mid-1930s (15:206-207). Carriers seeking refuge from excessive competition formed the Air Transport Association (ATA) in 1936. Almost immediately, the ATA began lobbying for new legislation to unify air regulation and promotion in one federal agency that could provide a stabilizing force for the industry (29:106). Thus, the 1938 Civil Aeronautics Act created the Civil Aeronautics Authority, later renamed the Civil Aeronautics Board (CAB) (15:207).

The regulatory system established in 1938 remained essentially the same into the late 1970s (10:571). The following provisions applied to the regulation of passenger fares (10:575; 15:208):

1. Airline fares were to be just and reasonable.
2. Undue discrimination was prohibited.
3. Carriers had to file all fares with the CAB.
4. Thirty days' notice was required before a fare could be changed.
5. The CAB could suspend and investigate fare proposals for up to 180 days.
6. The CAB could investigate existing fares after a complaint or on its own initiative.
7. Carriers had to publish rates in tariffs and could not

deviate from the published fares.

Following an investigation of existing or proposed fares, the CAB could prescribe maximum, minimum, and/or actual fares to be charged. In determining such fares, the CAB was required to consider, among other things (10:575,576; 15:208):

1. The effect of such rates upon the movement of traffic.
2. The need of the public for adequate transportation at the lowest cost consistent with the furnishing of such services.
3. The need of each carrier for revenue to provide adequate and efficient service.

While the Civil Aeronautics Act of 1938 required the CAB to consider the revenue needs of the carriers in evaluating fares, no specific standard for determining those needs was set forth. The CAB conducted extensive investigations into the pricing of passenger services in the late 1950s. As a result of their findings, the rate-of-return-on-investment was established as a guide in evaluating revenue needs (10:576).

A similar investigation, known as the Domestic Passenger Fare Investigation (DPFI), was conducted from 1970 to 1974. Policies adopted by the CAB as a result of this investigation included the principle that fares should be based on costs rather than demand (10:576). The result was an inflexible rate-of-return fare structure for coach service based on the industry's average costs. Regarding the resultant formula, Taneja (26:81) writes:

The formula was inflexible in that it produced identical fares for all equal-distant markets even though a higher or lower fare might be warranted, based on cost or marketing considerations. Individual carriers were allowed to file across-the-board changes (upward or downward) in the entire

structure but could not adjust fares in particular markets. The only way to compete on price in an individual market was either to offer a restricted promotional fare or establish a new class of service.

The DPFI also determined that certain promotional (discount) fares--for example, those based primarily on age and family status--were unjustly discriminatory against payers of regular fares. Since unjustly discriminatory practices were in violation of the Civil Aeronautics Act of 1938, it became CAB policy to eliminate promotional fares (1:55; 10:576).

While regulation of the airline industry had been questioned as early as 1951, it was not until the 1970s that the anti-regulation movement gained serious momentum. During the mid-1970s, the airlines began suffering severe financial difficulties when sudden increases in capacity, a result of acquiring wide-bodied aircraft, coincided with a serious economic recession and a massive increase in fuel cost, a product of the 1973 Arab oil embargo. It was in this atmosphere that an influential report was released by the Subcommittee on Administrative Practice and Procedure of the U.S. Senate Judiciary Committee, headed by Senator Edward Kennedy. Throughout the report the message was clear: "prices should and would be lower with a more competitive system" (3:8-9).

Contrary to the CAB's official policy against promotional fares, economic conditions (and perhaps political pressures as well) prompted the CAB to approve, starting in the spring of 1977, various kinds of promotional fares. The CAB's reasons for approving such variations against its own policy were to promote carrier efficiency and to improve the carriers' allocations of resources. Because the CAB was reluctant to

approve deep promotional price cuts, however, competing carriers were often able to propose matching fares, so fare uniformity continued to exist in the industry (10:577; 26:81).

Perhaps the most significant step toward regulatory reform came when President Jimmy Carter began appointing people to the CAB who were sympathetic to deregulation (10:579). Among the appointees was Alfred E. Kahn, named chairman of the CAB in June 1977 (15:234).

Impatient with Congress' failure to pass deregulatory legislation, Chairman Kahn decided, on his own, to start reducing CAB control of the airline industry (26:1). A new fare flexibility rule was adopted which established a suspend-free zone ranging from 10 percent above to 70 percent below the existing DPFI coach fare. Within this range, carriers could file fare proposals without the economic justification previously required. Carriers could further expect such proposals to be approved as long as no other party could prove that such a fare would cause irreparable damage to competition (26:82).

The Airline Deregulation Act of 1978 practically "rubber-stamped" the fare guidelines already adopted by the CAB. The Act withdrew the CAB's authority to judge the reasonableness of a proposed fare if such a fare would not be more than 5 percent higher nor 50 percent lower than the Standard Industry Fare Level, the fare in effect for that route on 1 July 1977. There were two general exceptions to this "zone of reasonableness," as it was known in the industry (3:12; 10:583):

1. The CAB maintained control over fare increases proposed by a carrier with 70 percent or more of the air passenger market over that route.
2. The CAB continued to have authority over fare decrease proposals if the reduction would be predatory.

Perhaps the most significant effect of the Airline Deregulation Act of 1978 was the gradual elimination of federal economic regulation of domestic air transportation. Federal regulation of passenger fares ended on 1 January 1983 and the Civil Aeronautics Board closed on 1 January 1985 (3:12; 10:581,583).

#### Current Conditions

Pricing freedom is undoubtedly the most visible sign of airline deregulation (16:31). By March 1983, use of discount air fares had risen to 87 percent of all air passengers (3:46). The average discount in 1983 was 48 percent of the regular coach fare (28:181). While these facts fuel the widespread public impression that deregulation has produced lower fares, availability of lower fares is certainly not universal. On some routes, fares have been reduced to levels below those of 1978; but on other routes, fares have as much as tripled or more (3:33).

In describing current practices in airline pricing, Robert L. Crandall, chief operating officer of AMR Corporation (the parent company of American Airlines), jokes about "the adjustable rate fare--tell us what you can afford and we'll sell you a ticket" (14:24). What Mr. Crandall alludes to is the sharp disparity in airline pricing since deregulation.

Indeed, super bargains exist in some markets. For example, in October 1984, one could travel from New York to Los Angeles for 32 percent less than it cost in 1978. However, "The fact remains that airline fares, overall, increased about 50 percent during the first six years of deregulation" (28:176). In some markets, fares have more than

tripled. The lowest "effectively available" fare (one an average passenger would have a reasonable chance of getting) between Cincinnati and St. Louis rose 231 percent between April 1978 and April 1984 (3:36-37,136).

Prior to deregulation, under the CAB's rate making rules, a traveler could expect that routes of approximately equal length would have fares that were nearly equal. That condition no longer holds true. Lack of competition induces prices on lightly traveled routes to remain high in comparison to routes of similar length but higher passenger volume (8:56). For example, the distance by air from New York to Amarillo, Texas, is only two miles more than from St. Louis to San Diego. In April 1984, the lowest effective one-way fare for the New York-Amarillo route was \$350, while the lowest St. Louis-San Diego fare was only \$159 (3:36).

A wide disparity in fares may exist even over essentially equivalent routes, depending on the airport a traveler uses. In the fall of 1984, a passenger flying to Minneapolis from Chicago could travel for only \$50 if he/she left from Midway Airport. Using the same airline, such a passenger would have been charged \$155 to leave from Chicago's O'Hare Airport (28:176-177).

Moreover, even on a single flight one is likely to find passengers who have paid a dozen or more different fares for the same transportation. The factors that determine such pricing will be discussed later in this chapter.

Disparity in pricing would be difficult enough to analyze in a stable market. Unfortunately, deregulated airline pricing is highly volatile, making it virtually impossible to present a detailed, fully

accurate picture of the situation (3:34). A Time magazine article on air travel in October 1984 reported that United Airlines alone makes 3500 fare changes a day (8:56). "In this environment, any comparison of fares developed at one point in time will be out-of-date within days, or at most weeks" (3:35). Yet, airline companies and users alike must develop fare comparisons to at least identify the industry trends which may impact their management decisions. Airline companies must compare fares to ensure they remain competitive; users must ensure they receive optimum benefits for their travel dollars.

#### Price Competition

No-frills discount airlines have been the strongest force for change in the airline industry since deregulation began. People Express, the fastest-growing company in aviation history, has been the boldest pioneer (8:56-57). When People Express began moving into most of the major routes starting in the spring of 1984, incumbent carriers faced a special dilemma:

On the one hand, they could not afford to let People Express establish too strong a foothold as the one carrier with the best "bargain". On the other hand, the size of the routes (and their relative importance within each carrier's traffic and financial structure) also meant that it was critical to resist any greater erosion of yield on these routes than absolutely necessary. (3:43)

Labich echoes that sentiment: "Once an airline elects to keep flying against a low-cost rival, it must decide whether to start cutting fares. . . . The airline . . . has to guess whether it will lose more by cutting fares or giving up market share" (14:26). Most large airlines match the low prices. They have a decided advantage in that, because of the size of their systems, they are bound to have some less traveled

routes without significant competition. The airline can use high yields on the less traveled routes to "fill their war chests" so they can stay in the air on routes where they face fare cutting (14:27).

#### Service Competition

Prior to deregulation, industry observers predicted that the freedom to compete in price would preclude the necessity to vie through service features and amenities. However, since price cuts by one carrier are usually matched by other carriers, price ends up as a neutralized factor rather than a basis for differentiating among carriers (3:28).

One peculiarity of most low-cost airlines is that fares rarely include such things as baggage checking, beverage service (not even juice or soft drinks), or meal service. For example, People Express, while keeping the cost of a basic ticket low, charges \$3 for a checked bag and 50 cents for a cup of coffee (14:28).

A common advertising theme used by airlines competing against low-cost carriers is: "We have the same low price as Airline X. But our airline gives more and better service features for that price" (3:28). For example, United Airlines responded to People Express' Newark, New Jersey, to Chicago fares by claiming it would match People's fares "without sacrificing amenities such as free baggage handling and meals" (14:26).

#### Pricing Factors

The ideal situation for a carrier would be to sell all available seats at full coach fare. Of course, with competitors offering lower fares, such a strategy could be disastrous for the airline. The primary

reason a carrier establishes discount fares is to stimulate travel and fill seats that would be empty if they charged only the full fare (3:45). Discount fares, then, are based on "the economy of the empty seat" as well as demand elasticity.

Once a carrier commits to a particular flight, the costs of crew pay, fuel, landing fees, maintenance, and depreciation become sunk costs and will not be affected by whether there are 150 passengers or 151 aboard. Because the marginal cost of a single empty seat is almost nil, airlines prefer any proceeds to the zero revenue to be garnered from a seat left empty (3:38). Discount fares are designed to sell each empty seat.

To improve the probability that its airplane would be full, a carrier could sell all seats at a discount. While this would certainly be an ideal situation for the traveling public, again it could be disastrous for most airlines because the carrier may not be able to cover all costs if all seats are offered at low rates. To maximize revenues, then, a carrier must attempt to sell as many seats as possible at full coach fares and offer the rest at a discount.

According to Gwartney and Stroup (9:162), to effectively implement price discrimination--charging different prices to different groups of consumers--two primary conditions must be fulfilled. First, "there must be at least two identifiable groups of consumers whose price elasticities of demand for the firm's product differ." Most discount fares are designed to lure discretionary travelers, primarily people engaged in pleasure or vacation travel, as opposed to business travelers. If air fares are too high, the discretionary traveler is likely to change to

another mode of travel or cancel his/her plans altogether (3:46).

The second condition advanced by Gwartney and Stroup is, "The seller must be able to identify and separate these consumers at a low cost" (9:162). To be successful, a discount fare must be structured so as to screen out business people who would likely require travel regardless of the price (lower demand elasticity). This is the reason for the development of discount fare restrictions. Discount fares commonly carry various restrictions based on round-trip travel, off-peak travel, length-of-stay and/or weekend stay, advance purchase requirements, and/or capacity control restrictions (i.e., a limited number of seats are available at those fares). Discretionary travelers can usually fulfill these requirements for discount fares, while business travelers are usually less flexible (3:45).

Even when travelers can be separated by their demand elasticity, a carrier trying to maximize revenue will try to avoid selling seats at discount fares that could have been sold at the full coach fare. It is this philosophy which leads to the strategy of capacity control. United Airlines and American Airlines, who together carry one-third of all commercial traffic on U.S. routes, severely limit the number of discount seats they offer on peak-hour flights (14:24). "United uses its computerized 'capacity control' system to plan allotments in advance and capture the maximum revenue for each flight" (14:26). They offer few discount fares for midweek flights they can fill with business travelers paying full price. On such a flight, less than 10 percent of the passengers might be paying the lowest available fare. "On weekends or late at night, United loads up seats that would otherwise be empty" with

discount passengers (14:26).

American Airlines has 130 people who spend their days at computer terminals monitoring ticket sales on flights up to 11 months in advance. The operators' job is to make adjustments in the proportion of discount seats offered. As a result, the balance of discount and full-fare tickets available continually changes. A passenger unable to buy a discount ticket for a particular flight today might be able to purchase one on the same flight tomorrow (14:26-27).

People Express believes that capacity control strategies are unfair to the traveling public. "It's a bait-and-switch operation," the chairman of People Express says. "You call and they don't have the fare you wanted, but they can take you for a much higher rate. You're on the phone, so you just go along" (14:27).

#### The Contract Air Service Program

The U.S. Government is considered one of the "big winners" under deregulation (16:32). The Contract Air Service Program, started in July 1980, provides special fares for government employees (military personnel and civilians of all departments and agencies) traveling on official business aboard certain domestic flights. The program started with four carriers servicing 11 routes. At present, 25 carriers participate in the program, providing service to over 1000 city-pairs (routes between given pairs of cities) (5; 25).

The General Services Administration (GSA) annually invites airlines to submit bids on the amount of unrestricted discount each line would offer on certain city-pairs selected by GSA and the Military Traffic Management Command (MTMC). A joint GSA/MTMC working group evaluates the

offers and contracts are awarded granting carriers preferential shares of government travel on the selected routes (16:32; 25). Carriers are selected for the program based on the best combination of low, unrestricted fare offers and frequency of service between requested city-pairs, including service to multiple airports where needed. In addition to offering the contract fares for government employees, some carriers have agreed to permit cost-reimbursable contractors to purchase contract fares when traveling on official government business (5; 13; 25).

Contract fares generally range from 40 to 70 percent below standard coach fares. The Federal Travel Directory listing contract routes, carriers, and fares is published monthly and distributed for use by all government travel managers. The Contract Air Service Program has saved the government approximately \$200 million off regular coach fares since its inception (3:48-49; 4; 5; 13).

Subsequent to the award of Contract Air Service Program contracts, competing non-contract carriers frequently offer fares equal to or lower than the contract fares. The limiting factor of the Contract Air Service Program is that, while lower fares may exist, the government remains obligated to use the contract carriers (13).

Where contract air service exists, it is mandatory to use the contract carrier as long as seats are available, flight schedules meet the traveler's mission requirements, and no other carrier offers a lower totally unrestricted fare. (12)

#### Summary

Airline pricing strategies have changed dramatically since the Contract Air Service Program began in 1980. With the current pressures

to reduce government spending, all existing programs must be reexamined to ensure we receive maximum benefits from every dollar we spend.

Because deregulation has generated a wide range of fares, it is no longer appropriate to measure the effectiveness of the Contract Air Service Program by comparing program expenditures against unrestricted coach fares alone. The efficiency of the program can be estimated more realistically by using a cross section of airline fares as a standard for comparison.

Even if the Contract Air Service Program is found to be beneficial at the present time, future transportation managers at the Military Traffic Management Command (MTMC) and General Services Administration (GSA) will be able to use the simulation model developed in this study to periodically reevaluate the program. Future conditions can be analyzed simply by updating the model parameters for the government travel characteristics and commercial airline fare structures. Information provided through these updates can assist MTMC and GSA program managers in negotiating with participating carriers or identifying if the program has outlived its usefulness. With the amount of money spent on the Contract Air Service Program [over \$82 million in fiscal 1985 (4; 20; 21; 22)], even a small percentage change through increased use of better discount fares can be significant.

### III. Methodology

A realistic evaluation of the Contract Air Service Program must include a comparison of contract fares with a cross section of other available airline fares. The literature review has described the highly complex nature of current airline fare structures. Computer simulation is one of the most important and useful tools for analyzing the design and operation of such complex systems (24:1).

Banks and Carson (2:2) describe simulation as "the imitation of the operation of a real-world process or system over time." Simulation, then, involves generating an artificial history of a system based upon model assumptions. This artificial history is then analyzed and used to predict the manner in which the real system would behave under analogous circumstances (2:11).

Among the primary advantages of simulation are (2:4; 6; 18:4-5):

1. One can analyze a system even though the input data are not well defined.
2. One can experiment with an existing system without disturbing it or destroying it.
3. Once a model is built, one can use it repeatedly to analyze proposed designs or policies.

Reitman (19:10) also explains the key importance of flexibility in simulation:

Once a model is developed with a reasonably flexible structure, then it can be quickly and cheaply varied to include new wrinkles. . . . It makes for friendly relations to be able to use the same model to evaluate additional alternatives.

Simulation is well suited for this study. First, the diversity, complexity, and volatility of the airline fare structures limit the

definability of that portion of the input data. Second, through simulation, the effects of modifying or even cancelling the Contract Air Service Program can be estimated without actually altering or terminating the program. Finally, the model can be used to investigate a wide variety of "what if" questions. Future transportation managers at the Military Traffic Management Command (MTMC) and General Services Administration (GSA) can use the model repeatedly to estimate the effects of changes in government travel characteristics and commercial airline fares on the benefits of the Contract Air Service Program.

#### Language Selection

Shannon provides a comprehensive list of factors to be considered in selecting a simulation language (24:107-108). Simulation Language for Alternative Modeling (SLAM II) was chosen for this thesis for a number of reasons. First, the language was taught as part of the curriculum in the Graduate Logistics Management Degree Program at the Air Force Institute of Technology; thus, the text and experienced personnel were available to assist in the resolution of problems. Second, SLAM II is an easy to use language, is very self documenting when written properly, and has good error diagnosis capabilities; these characteristics facilitate model building and modification. Finally, SLAM II is available in a wide variety of microcomputer versions (18:vii), one or more of which may run on MTMC and/or GSA equipment.

#### The Systems Science Paradigm

The methodology used in this research is an expansion of the Systems Science Paradigm expressed by Schoderbek, Schoderbek, and Kefalas

(23:295-304). The Systems Science Paradigm is an "application of the systems approach to the study of real-world phenomena." It consists of three successive phases: Conceptualization, Analysis and Measurement, and Computerization.

#### Conceptualization

The first phase of the Systems Science Paradigm is the conceptualization of the problem, defined by Schoderbek, et al., as:

understanding and organizing the interactions among the elements making up the phenomenon under scrutiny into a logical network of relationships in such a way as to reveal the direction of the underlying structure. (23:290)

The variables which interact within the system, and between the system and its environment, must be examined. The model should include only those independent variables determined to be relevant to the accomplishment of the stated objectives. The model should be structured to permit the measurement of the dependent variables to determine whether or not the stated objectives have been met.

The conceptualization of the problem addressed in this study was introduced in Chapter 1. The Contract Air Service Program includes over 1000 routes (5; 25). Because time limitations dictated that the research objective be restrained to the development of a prototype, rather than a fully developed, model, this simulation is based on a sampling of ten routes rather than a census of the entire population of routes.

This simulation model is built on the network approach, which offers relative ease in programming and in executing the model on the computer. Perhaps even more important, however, is the potential for even an inexperienced person to be able to look at the model, understand the

process, and modify it to test alternatives (17:18-20).

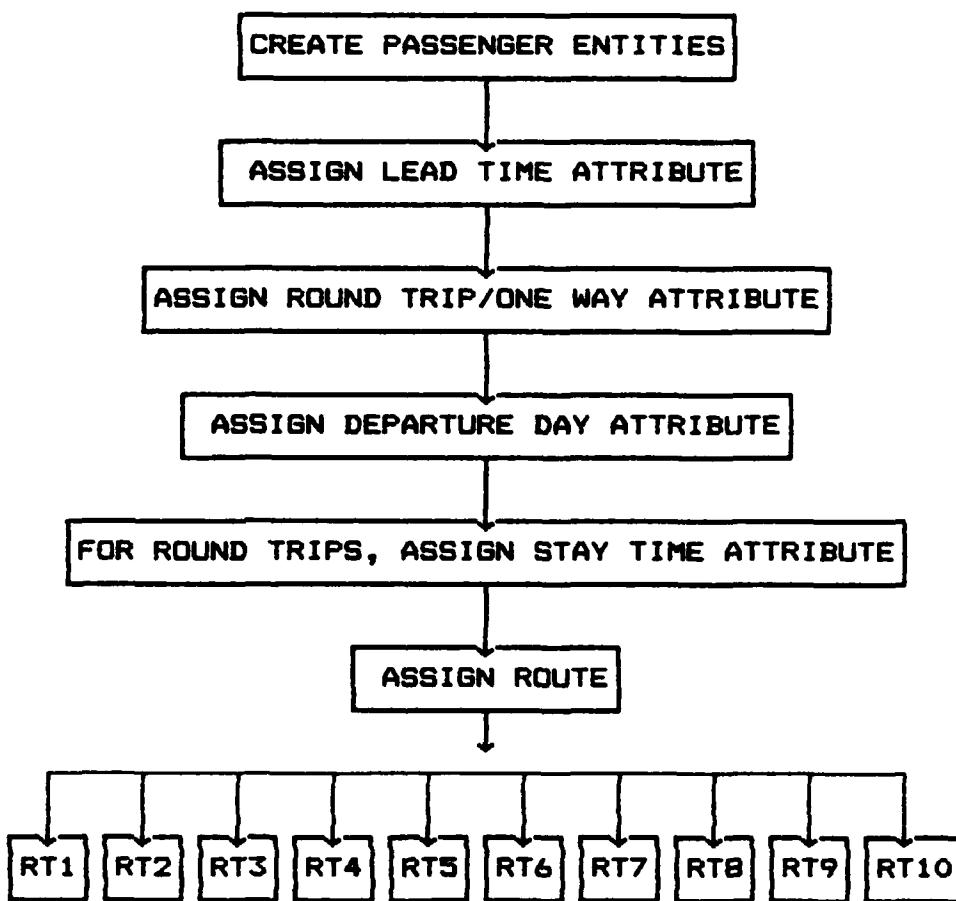
The network developed for this simulation is illustrated in general terms in Figure 1. The network modeling approach consists of defining the system as a set of entities which flow through a system of decision points, called nodes. An entity can represent a person, a vehicle, or whatever the modeler wants it to be (17:18). In this model, entities represent passengers.

According to The Official United States Passenger Tariff, the applicability of individual air fares is dependent on one or more factors (27). Among the primary determining factors are:

1. The route.
2. Whether the travel is round trip or one way.
3. The lead time - the number of days between the time the ticket is issued and the day travel is to be initiated.
4. The day of the week that travel is to be initiated.
5. The stay time - for round trip travel only, the number of days between a traveler's arrival at his/her destination and his/her return from that location.

One factor not included in this model is blackout dates, dates on which a discount fare does not apply (particularly holidays and other peak travel periods).

Entities may be assigned attributes, characteristics of the entity, that enable the modeler to distinguish between individual entities (18:79). In this model, for example, one attribute of each entity is the lead time of the passenger. Each of the factors for determining air fare applicability is represented as a separate attribute of each entity. The attributes, then, may be viewed as the independent variables of this model.



FOR EACH ROUTE:

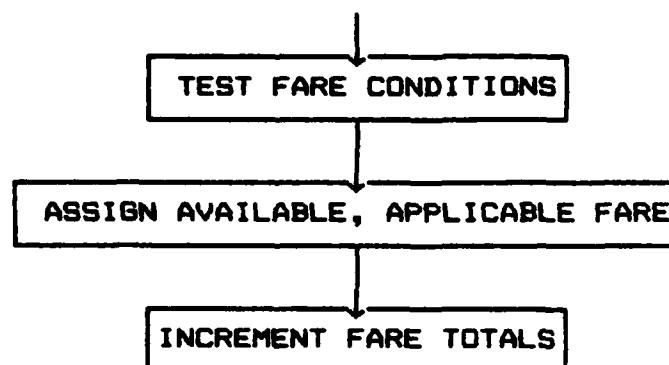


Figure 1. General Network Flow Chart

The actual path of an entity through the network is largely dependent on the values of its attributes as it passes through each node. At any given node, one value of a particular attribute may direct the entity to one activity, while a second value will direct it to another. Eventually having been directed along the proper paths of the network to the branch representing the cheapest available fare for which it is qualified, the entity will cause the route-specific and system-wide fare variables, the dependent variables of the model, to increase.

#### Analysis and Measurement

Route Selection. Route selection for this model is based on the double sampling or multiphase sampling technique (7:316). Double sampling involves the collection of information by some initial sample and then using that information as the basis for selecting a subsample for further study.

The first phase of the double sampling was the selection of fifteen candidate routes through stratified sampling (7:306-312). "Stratification is almost always more efficient statistically than simple random sampling" (7:307). Stratification involves segregating a population into a number of mutually exclusive subpopulations, or strata.

The primary purpose of selecting routes by stratification was to ensure the representation of routes with various volume-fare combinations (for example, routes with high passenger volume and high coach fares). The Contract Air Service Program routes were segregated based on three levels of passenger volume (high, medium, and low) and three levels of coach fares (also high, medium, and low). The routes were sorted into one of nine cells of a three-by-three volume-fare matrix. A random

sample was then taken from each of the nine cells according to the cell's proportion of the total number of routes.

Segregation of routes by passenger volume was based on data for fiscal 1985 listed in quarterly reports from the Directorate of Passenger Traffic, Headquarters, Military Traffic Management Command (4; 20; 21; 22). A simple Fortran program was generated and applied to the quarterly data to yield annual passenger volumes by route. The data indicated that only 391 of the 1000-plus Contract Air Service Program routes had been utilized during the year.

Fare data was obtained through The Official United States Passenger Tariff (27). The highest unrestricted fare available on each route on 31 May 1986 was used as the basis for comparison because of the greater potential for savings or extra cost, depending on the applicability or inapplicability of discount fares. Each route's fare data was merged into a common file with the route's corresponding volume data for further processing.

The goal of the next step was to divide the passenger volumes and fares into three equal categories each. A program for the SPSS-X statistical package was executed on the composite volume-pax data file to identify the 33 1/3 and 66 2/3 percentiles by passenger volume and by coach fare. The dividing points for passenger volume were found to be 162 2/3 and 1188.

Because thirty routes had \$330 fares which fell on the 66 2/3 percentile, it was not possible to divide the fares into three equal categories. The \$330 fare routes were classified as medium fare routes, leaving the high fare category with fewer routes than the other two

categories. This had no real effect on route selection since routes were to be selected from each cell of the volume-fare matrix based on their proportion of the total number of routes. The dividing points for route fares were \$247 and \$330.

A second SPSS-X program was run to cross tabulate the three passenger volume categories with the three coach fare categories. This was necessary to determine the number of routes in each of the nine cells of the matrix, so routes could be selected proportionately. The matrix resulting from this cross tabulation is shown in Table I. The numbers in each cell depict the number of routes which fit the criteria for that cell and the cell's percentage of the total number of routes.

Another Fortran program was developed and applied to the composite volume-fare data file to sort and list the 391 routes according to their proper cells in the volume-fare matrix. As they were listed, the routes in each cell were assigned unique consecutive numbers to facilitate random route selection from each cell in the next step.

Since 15 routes were needed from this first route selection phase, and based on the allotment of routes within the volume-fare matrix, it was determined that two routes would be selected from each cell, with three exceptions. Only one route would be selected from the three cells with the fewest number of routes: the cells representing high volume and high cost, medium volume and high cost, and low volume and low cost.

For each cell, random numbers were obtained using the "runif" (random uniform) generator of the S programming language. These numbers were then cross referenced with the route listing for that cell and the appropriate routes were selected to enter the second phase of the double

TABLE I  
Route Volume-Fare Matrix

Passenger Volume	Cost			Row Totals
	<\$247	\$247-330	>\$330	
>1188	59 15.1%	54 13.8%	17 4.3%	130 33.2%
163-1188	38 9.7%	59 15.1%	34 8.7%	131 33.5%
<163	33 8.4%	45 11.5%	52 13.3%	130 33.2%
Column Totals	130 33.2%	158 40.4%	103 26.3%	391 100.0%

sampling. The routes selected are shown in Table II.

The second phase of the double sampling route selection process involved scaling down the list of routes to be modeled to ten routes. The purpose of this phase was to arrive at a more manageable scope for the prototype model by eliminating routes over which there was the least potential for Contract Air Service Program contract fares and other discount fares to impact total savings.

Discount fares are least likely to have impact on potential savings over routes where either the volume is low or the coach fare is low. Thus, scaling down might have been accomplished prior to the initial route selection by eliminating from consideration routes identified as low fare routes, for example. Because total costs result from an interaction of volume and unit costs, however, even a low fare route may

TABLE II  
Model Route Selection

Route	Passenger Volume	Volume Class	Coach Fare	Fare Class	Max Tot Cost (\$000)
Boston-Washington	69,021	High	\$210	Low	\$14,494
New York-Syracuse	2,541	High	\$130	Low	\$330
Indianapolis-Philadelphia	1,249	High	\$250	Medium	\$312
Minneapolis-Washington	12,752	High	\$290	Medium	\$3,698
San Diego-Washington	1,372	High	\$530	High	\$727
Columbia (SC)-Louisville	939	Medium	\$195	Low	\$183
Hilo-Kahului	269	Medium	\$69	Low	\$19
Chicago-Madison	739	Medium	\$290	Medium	\$214
Dallas-Des Moines	217	Medium	\$330	Medium	\$72
Denver-Pittsburgh	561	Medium	\$370	High	\$208
*Atlanta-Memphis	31	Low	\$214	Low	\$7
*Boston-Minneapolis	7	Low	\$330	Medium	\$2
*Chicago-Corpus Christi	50	Low	\$330	Medium	\$17
*Cleveland-San Diego	12	Low	\$460	High	\$6
*Memphis-New York	16	Low	\$355	High	\$6

\* = Routes eliminated from consideration in Phase II

engender significant potential for savings if the volume is high. By the same token, low volume routes are not inherently insignificant; the potential for savings on each low volume route is also dependent on the fare charged. Because of the weaknesses of this somewhat arbitrary approach, it was disregarded as a means to limit the scope of the prototype model.

The list of routes to be included in the prototype simulation model was scaled down by eliminating the five routes with the lowest maximum total coach costs, based on data used in the initial route selection phase. The maximum total coach cost for each route is shown in thousands of dollars in the right hand column of Table II. Routes eliminated in

this second phase are indicated by an asterisk. The insignificance of the five eliminated routes is evident in the fact that they total only \$36,644, or 0.18% of the \$20.3 million maximum total cost for all 15 routes.

Ultimately, all eliminated routes were low volume routes. It is easy to see, however, that had the Hilo-Kahului route volume or fare been slightly lower, that route would have been eliminated rather than the Chicago-Corpus Christi route. This, then, is a prime example of the reason the low volume routes should not have been arbitrarily eliminated as a class.

Fare Data Collection. Once the routes for the prototype simulation had been selected, data on available fares could be gathered from The Official United States Passenger Tariff (27). The ten selected routes were alphabetized to aid in searching for applicable fares and were numbered as follows for ease in coding the computerized model:

1. Boston-Washington
2. Chicago-Madison
3. Columbia-Louisville
4. Dallas-Des Moines
5. Denver-Pittsburgh
6. Hilo-Kahului
7. Indianapolis-Philadelphia
8. Minneapolis-Washington
9. New York-Syracuse
10. San Diego-Washington

As discussed in the literature review, most routes offer dozens,

even hundreds, of different fares. Because the model to be developed is a prototype rather than a fully developed simulation model, fare data gathering was limited to six general fare classifications for each route.

A preliminary phase to fare data collection, then, was to identify four or five general fare classifications (in addition to the full coach fares) available to government personnel traveling on official business over most, if not all, of the ten selected routes. Fares for senior citizens, families, and military personnel on leave, for example, were not considered.

Fare classifications common to all ten routes were sought to facilitate the development of network logic which could be duplicated for each route and to improve the basis for comparing output statistics gathered from different routes. The fare classifications selected for the prototype simulation model are shown in Table III.

The goal of identifying fare classes available over all ten routes was not met in that no excursion (E-series) fares were offered on the Hilo-Kahului route. Two capacity-controlled one way discount fares were offered, however. All other fare classes were available on each of the other routes, except the Chicago-Madison route, which had no E21 fares.

Each of the E-series fares is usually prefixed with a B, Q, or K. These prefixes have no particular meaning except that different airlines use different prefixes. There is no implied difference in class of service. A carrier may even change prefixes from time to time. The same conditions are true of the one way B, Q, and K fares (11).

Each fare class may also have a suffix to indicate the day or days of the week it is in effect. The days of the week are numbered from one

TABLE III  
Selected Fare Classifications (27)

<u>Fare Classification</u>	<u>Round Trip/ One Way</u>	<u>Capacity Controlled</u>	<u>Advance Purchase</u>	<u>Minimum Stay</u>	<u>Maximum Stay</u>
E30	Round Trip	Yes	30 Days	Sunday	21 Days
E21	Round Trip	Yes	21 Days	Sunday	21 Days
E14	Round Trip	Yes	14 Days	Sunday	30 Days
E70	Round Trip	Yes	7 Days	Sunday	60 Days
B, K, & Q	One Way	Yes	None	N/A	N/A
Y	One Way	No	None	N/A	N/A

to seven beginning with Monday. A suffix beginning with an "X" indicates the fare is effective except for the days specified. A suffix beginning with a "D" or "Z" indicates the fare is effective only on the days specified (27). For example, a fare ending with "X67" would be applicable for departures on weekdays only, not on Saturday or Sunday. Conversely, a "Z23" fare would be applicable only for departures on Tuesday or Wednesday.

Once the fare classes were identified, actual fare data gathering was begun. All fares in the specified classes effective on 31 May 1986 were recorded for each of the ten selected routes regardless of the number of airlines or flights to which they applied.

Model Development. A general network flow chart was shown in Figure 1 (page 22). The next step in the Analysis and Measurement phase was to refine the simulation concepts into model logic that could then be

translated into SLAM II computer code.

The discussion of the conceptualization phase pointed out that the entities in this simulation represent passengers. All other aspects of the simulation center on the passenger-entities and their attributes (travel characteristics).

A key element to simulation is the rate at which entities enter the system. The most important model for random arrivals is the Poisson arrival process (2:176). The Poisson process has been successfully employed to model the arrival of people at restaurants, drive-in banks, and other service facilities. Poisson arrival rates are normally expressed in terms of the mean number of arrivals in a specified time period (for example, 40 customers per hour).

The creation of entities in SLAM II is based on the time between creations rather than the number of creations in a particular time period (Poisson). To implement a Poisson process, then, it is necessary to transform the mean arrival rate to a mean interarrival time. Poisson interarrival times are exponentially distributed, the mean of which is the reciprocal of the corresponding mean arrival rate (2:161,176). For the purpose of this prototype model, the interarrival times of government employees requiring air transportation is assumed to be exponentially distributed.

The time units for this model are days and the standard simulation run is one year (365 simulation time units). It would seem that the mean Poisson arrival rate for the model could be determined by dividing the expected total annual passenger volume for the modeled routes by 365. The reciprocal of that value would then become the mean for the

exponential interarrival times. However, because many passengers make round trips between pairs of cities, total coach and contract fare costs over a particular route are a function of the number of trips over that route rather than the number of passengers traveling the route. That is, one passenger making a round trip between any pair of cities is equivalent to two individual passengers making one way trips between the same cities.

The creation of entities in this simulation, then, is modeled as a function of the expected volume (in total trips over all ten routes) and the proportion of those trips which are a segment of round trip travel. The number of entities required per run can be found by dividing the expected total annual trip volume by the sum of one plus the proportion of passengers expected to make round trips. This value should then be divided into 365 (the equivalent of dividing by 365 and then taking the reciprocal) to determine the mean interarrival time in terms of days. The whole process can be summarized by the following equation:

$$\text{MEAN INTERARRIVAL TIME} = 365 / [\text{VOLUME} / (1 + \text{RDTRIP})] \quad (1)$$

where

VOLUME = total expected annual trips

RDTRIP = proportion of passengers traveling round trip

An equivalent alternative to the above approach which bypasses determining the number of entities required, but requires one less division step is:

$$\text{MEAN INTERARRIVAL TIME} = [365(1 + \text{RDTRIP})] / \text{VOLUME} \quad (2)$$

One could evaluate the effects of different trip volumes and round trip proportions by manually calculating and entering new values for the mean interarrival times. For the sake of user friendliness, however, the model itself has been designed to calculate the mean interarrival time based on trip volume and round trip proportion parameters specified by the user.

In the prototype simulation runs, 89660 has been used as the target volume (the fiscal 1985 actual total trip volume for the ten modeled routes). It is further assumed that 90 percent of the passenger-entities will make round trips.

Once a passenger-entity has been created, it must be assigned attributes corresponding to the travel characteristics which will later determine the passenger's eligibility for various discount fares. The first attribute to be assigned is lead time. Lead time represents the number of days between the time a ticket is issued and the day travel is to be initiated. Lead times in this model are assigned using a SLAM II random variable generator.

Assuming it is more likely that lead time will be short rather than long, the lognormal distribution has been chosen as the lead time generator. To provide a good test of the workings of the prototype model, mean and standard deviation parameters were sought such that roughly 50 percent of the round trip passengers could, at least in terms of lead time (seven days or more), qualify for some discount fare. Likewise, it was desirable to select parameters whereby roughly ten percent of the round trip passengers could qualify for the deeper discount fares available with 21 days or more lead time. After several

experiments with a separate SLAM II program, it was found that a lognormal distribution with a mean of ten and a standard deviation of ten would satisfy the distribution objectives.

Because lead time is considered only in terms of integer days, Attribute 1 for each entity is assigned as the truncated integer form of the generated random variable. To avoid the theoretically unlimited lead times the lognormal generator could produce, a caveat is included in the model which recycles and recomputes any lead time in excess of 90 days.

The second travel characteristic to be modeled is whether or not the passenger-entity is traveling round trip. The round trip attribute, Attribute 2, is designed as a switch which starts as a "zero". A uniform random number generator, using the RDTRIP value (the same one used in determining the entity interarrival times) as the breakpoint, determines whether a passenger is traveling round trip or one way and, thus, whether or not Attribute 2 is reset. If the passenger is traveling round trip, the Attribute 2 switch remains "zero"; if the passenger is traveling one way only, the attribute is changed to "one". In the prototype model, RDTRIP is equal to 0.9, so ten percent of the passenger-entities will have Attribute 2 reset to equal "one".

The third attribute to be assigned represents the day of the week travel is to be initiated. The departure day attribute, Attribute 3, is, like Attribute 2, a switch. For Attribute 3, the switch has seven positions, one for each day of the week. A cursory survey of travel documents for 100 travelers who processed through the Wright-Patterson AFB Area B Traffic Management Travel Office yielded the departure day distribution shown in column two of Table IV. Departure day

TABLE IV  
Day of Departure Distributions

<u>Day</u>	<u>Survey</u>	<u>Model</u>
Monday	32%	30%
Tuesday	21%	20%
Wednesday	17%	15%
Thursday	16%	10%
Friday	3%	5%
Saturday	0%	5%
Sunday	11%	15%

---

probabilities actually implemented in the prototype model are shown in column three. A uniform random number generator, using the assigned probabilities as breakpoints, determines the passenger's day of departure. Attribute 2 is then assigned in convention with the codes published in The Official United States Passenger Tariff (27); that is, the days of the week are numbered from one to seven beginning with Monday. For a passenger departing on a Saturday, a "six" would be assigned to Attribute 3.

The next travel characteristic to be modeled is the stay time--the number of days between a traveler's arrival at his/her destination and his/her return from that location. Because this characteristic applies only to round trip travel, passenger-entities identified as traveling only one way bypass this step and proceed directly to the route determination phase.

Assuming that, like the lead times, stay times are more likely to be short rather than long, the lognormal distribution has been chosen as the

stay time generator. It is also assumed that, in comparison to the lead time distribution, there should be more stay times less than a week and greater variability toward the upper end of the distribution. To these ends, the parameters for the lognormal distribution of stay times in the prototype model are set at a mean of 10 and a standard deviation of 14.

Because stay time is considered only in terms of integer days, Attribute 4 for each round trip entity is assigned as the truncated integer form of the generated random variable. Again, as in the generation of lead times, a caveat is included to avoid the theoretically unlimited stay times the lognormal generator could produce. Entities initially assigned stay times in excess of 180 days are recycled and assigned a new stay time.

The fare determination routines to be developed for each route are divided into three primary subroutines, one each for round trip excursion fares, non-excursion round trip fares, and one way fares. Attribute 2 distinguishes round trip entities from one way entities, but there is no means, at this point, for distinguishing between round trip entities eligible for one or more excursion fares and those that are not.

To improve the efficiency of the model for simulation execution, it is advantageous to identify the entities that will not qualify for any excursion fare so they can completely bypass the excursion fare subroutine. It is also beneficial to make this identification before assigning routes rather than requiring the same tests be duplicated for each of the ten routes.

Application of each excursion fare class has unique prerequisites. However, a review of the excursion fare classes and their conditions

(Table III) reveals that, if a passenger cannot meet the restrictions for an E70 fare, he/she will not qualify for any other excursion fare either. To identify the entities ineligible for any of the excursion fares, then, we need merely to test the appropriate attributes against the E70 fare requirements:

1. The travel must be round trip.
2. There must be at least seven days' lead time.
3. The traveler must not return from his/her destination until at least the Sunday following his/her initial departure.
4. Stay time cannot exceed 60 days.

Attribute 5 is designed as a switch initialized for each entity as "zero" and reset to "one" for entities identified as ineligible for any excursion fare. For one way passenger-entities, Attribute 5 is reset at the same time as Attribute 2 and the entity bypasses the other three tests.

For round trip entities, if Attribute 1 (lead time) is greater than or equal to seven, condition two is met and the entity passes to the next test. Otherwise, Attribute 5 is reset to "one" (signifying a non-excursion fare round trip).

Condition three requires a more sophisticated approach. Because Sunday stay depends on the initial departure day and the stay time, two attributes must be tested and a separate pair of tests must be set up for each possible day of departure. For example, if Attribute 3 is set at "seven" (a Sunday departure) and Attribute 4 (stay time) is greater than or equal to seven, condition three is met and the entity passes to the test for condition four. If not, the entity passes to similar tests for

Monday and so on through the remainder of the week until it meets the conditions of one of the tests. If the entity passes through all seven tests without meeting any of their conditions, Attribute 5 is reset.

Condition four is also tested using Attribute 4. If Attribute 4 is less than or equal to 60, condition four is met. Otherwise, Attribute 5 is reset to "one".

To provide a general measure of the applicability of discount fares, a routine is inserted at this point in the simulation to count the number of round trip passenger-entities disqualified from consideration for excursion fares, as well as those that remain qualified. This is accomplished, of course, by counting the number of entities for which Attribute 5 is set at "one" and "zero", respectively. These values can then be compared to the round trip count or the total entity count to ascertain the proportion of travel which can be expected to qualify for excursion fares.

The final crucial step before entering a fare determination routine is to assign the passenger-entity to one of the ten modeled routes. This aspect of the simulation is modeled similar to the day of departure assignments. Probabilities are based on each route's proportion of the total ten-route passenger volume for fiscal 1985 (Table II). A uniform random number generator, using the assigned probabilities as breakpoints, assigns the passenger-entity's route. The entity then passes to the routine for that particular route.

The heart of the entire simulation model is the system of routines for the individual routes. Each routine follows the same basic framework, illustrated in Figure 2. The capitalized codes at the top of

ROUTE-SPECIFIC SUBROUTINES

SUBROUTINES ACCESSIBLE  
FROM ALL ROUTES

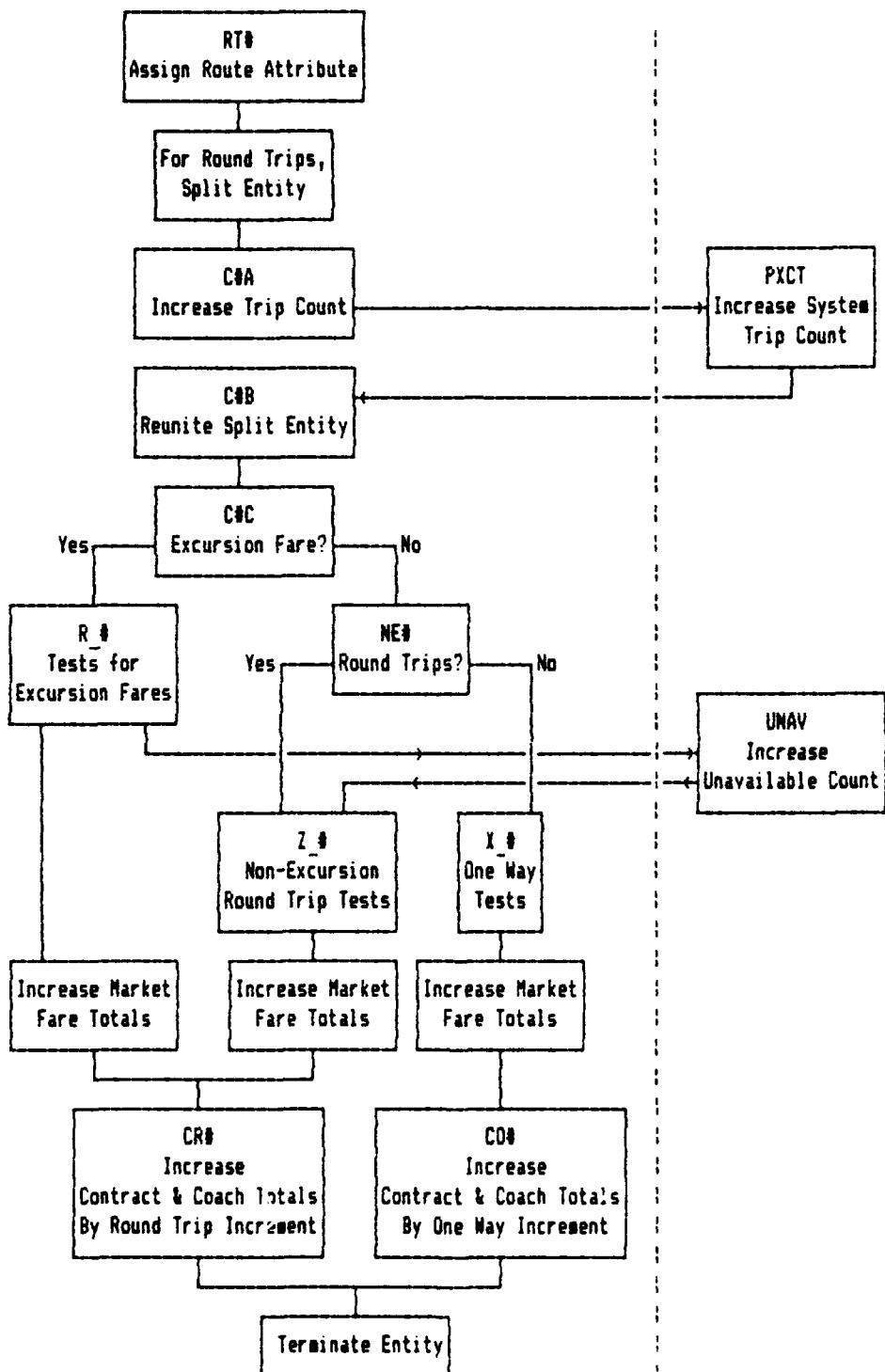


Figure 2. General Flow Chart for Individual Routes

most boxes are node labels used in the coded model as reference points for transferring an entity between different segments of the routine.

There are two model subroutines accessible from all route routines. A new attribute is needed to enable an entity to return to the proper route after passing through one of these subroutines. The first function in each route routine, then, is to set Attribute 6 equal to its route number (listed on page 28).

The objective of the next step is to facilitate counting the number of passenger trips over the route. A round trip entity must be split so that each half of the entity counts as a leg of the round trip. The entity split is accomplished by establishing two parallel paths to the counter, one of which is taken only if Attribute 2 is set at "zero". A round trip entity splits and follows both paths, while a one way entity takes only the unrestricted path to the trip counter.

After passing through the route trip counter, the entity or entity parts go to the system trip counter. This counter totals the number of trips for all ten routes. Then, based on the value of Attribute 6, the entity or entity parts are returned to their assigned route. Before proceeding to the applicable fare determination subroutine, entities which have been split must be reunited so only one fare is calculated.

As previously discussed, there are three primary fare determination subroutines. If Attribute 5 has not been reset to "one", the passenger-entity enters the first test for excursion fares. If Attribute 5 is set at "one" and the entity represents a round trip passenger (Attribute 2 has not been reset to "one"), it enters the test sequence for non-excursion round trip fares. If none of these conditions apply

(Attributes 2 and 5 both set to "one"), the entity enters the first test for one way fares.

Each of the fare subroutines is constructed on similar principles. Subroutine construction is also relatively consistent across routes. A partial flow chart for Route 7 (Indianapolis-Philadelphia) is shown in Figure 3. This particular segment illustrates all the conditions commonly encountered on all ten routes.

The first step in developing each fare subroutine was to arrange the applicable fares in ascending order, also listing each fare's prerequisites. The passenger-entity's attributes can then be tested against the requirements for each fare in succession from lowest to highest.

It should be noted that, since all entities entering the excursion fare subroutine have already been identified as round trip travelers and have been tested for the Sunday stay required for all excursion fares, those conditions need not be tested again. Lead times, departure days, and stay times will still need to be tested, as necessary, to differentiate the unique requirements for the different classes of excursion fares.

In the case of the excursion fare subroutine for Route 7, the lowest fare is an E30 fare for \$158. Since this fare requires 30 days' lead time and the maximum stay is 21 days, the entity passes to the next fare test (Node RB7, in this case) if its Attribute 1 is less than 30 or its Attribute 4 is greater than 21.

A passenger qualifying for a given fare may still not be able to obtain a ticket at that fare. Excursion fares in particular are capacity

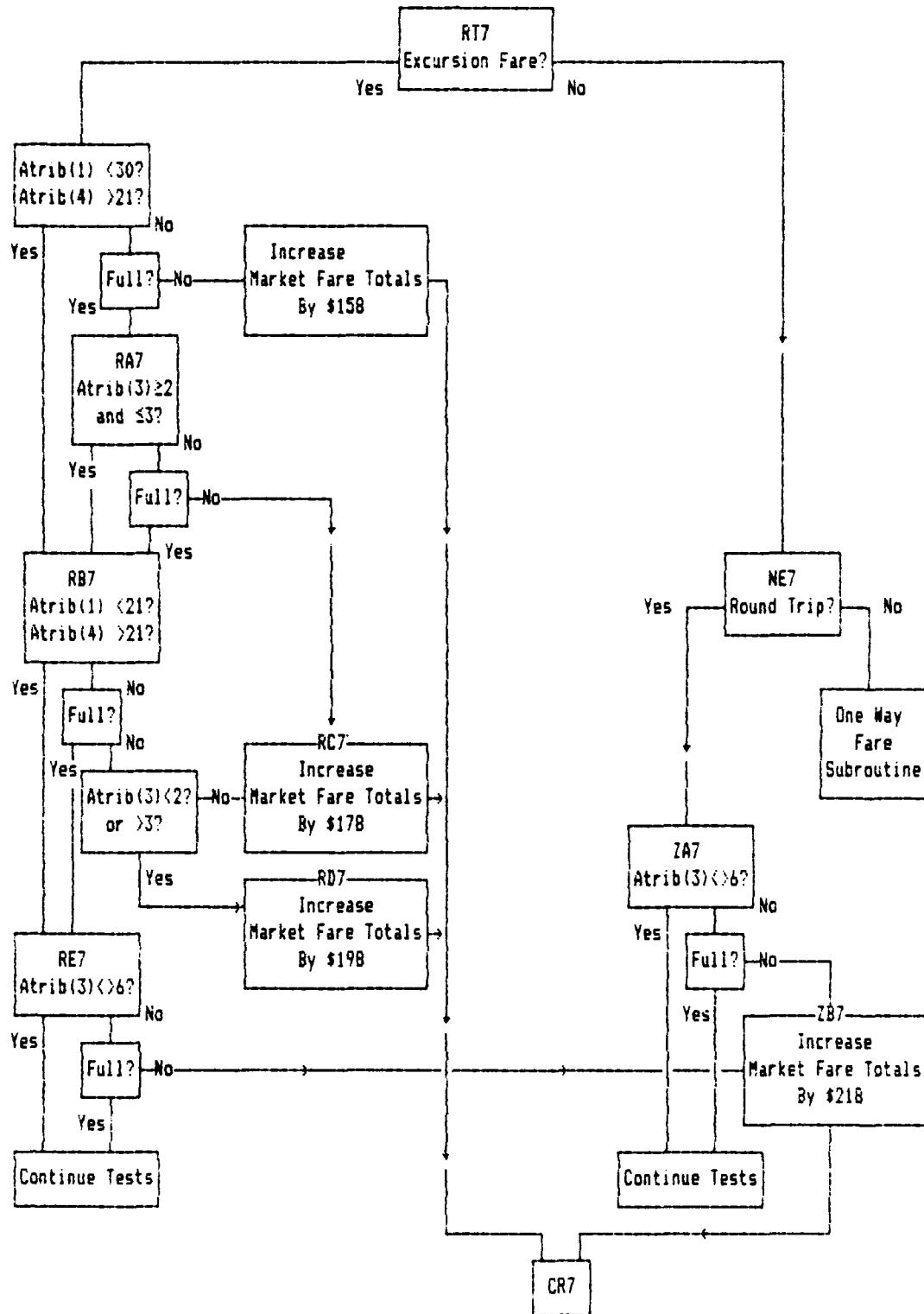


Figure 3. Partial Flow Chart for Route 7 Fare Tests

controlled and even full coach fares may be sold out from time to time. This model assumes flights are scheduled and seats made available (in terms of the size of aircraft assigned) based on demand.

In light of these assumptions, capacity controls and sell outs are modeled for this simulation as being relatively constant for non-coach fare classes, regardless of the airline. With a user-specified variable, FULL, as the breakpoint, the uniform random number generator determines whether or not an excursion fare ticket can be issued. Assuming the issue of regular coach fare tickets is also relatively constant, but less restricted, a second user-specified variable, COFULL, can be set to a lower value as the breakpoint for coach fare availability.

For the prototype simulation, it is assumed that 25 percent of the time any given excursion fare will be sold out. If that is the case, the entity passes to the next fare test. For coach fares, the breakpoint is set at 15 percent.

If, in the example from Figure 3, the E30 fares are still available, the market fare variable for Route 7 and the system market fare total are increased an increment of \$158. If not, the entity passes to Node RA7 for the next test.

The second lowest excursion fare is another E30 fare, this time an E30X23 fare offered only by TWA. Passenger-entities which could not meet the E30 restrictions in the previous attribute test have already bypassed this node, so, in terms of eligibility, the only attribute needing tested at Node RA7 is that for the day of departure. Since X23 fares do not apply for Tuesday or Wednesday departures, the entity passes to Node RB7 if Attribute 3 is set at "two" or "three". If it is not, the entity

passes to another seat availability test.

The E30X23 fare is the same as that for the E21Z23 fare yet to be tested. To avoid the need for duplicate routines to increase the fare totals, an entity qualifying for an available E30X23 fare is passed to Node RC7, where the fare totals can be increased for both cases.

The tests performed at Node RB7 are identical to those for the E30 fares, except for the values to which Attributes 1 and 4 are compared. For an entity which meets the basic E21 fare requirements, it would seem logical to next determine whether it is an E21Z23 or an E21X23 fare for which the entity is eligible, there being no non-suffixed E21 fares. Instead, the fare availability test is applied first. Testing the day of departure first would require a separate availability test for each fare. Since the same random number should be generated (and thus the same availability determination made) regardless of which Z23/X23 fare is applicable, it is more efficient to apply the availability test first.

The last common situation to be explained is the application of the BZ6 fare at Node RE7. The BZ6 fare is not an excursion fare, but a capacity controlled regular coach fare. The round trip BZ6 fare is less expensive than some of the excursion fares, so its applicability is tested before those fares. Since the BZ6 is not an excursion fare, the test for this fare can also be found in the non-excursion round trip subroutine at Node ZA7. As in the duplication of the TWA E30X23 and the E21Z23 fares, only one routine is needed to increase the fare totals to account for the BZ6 fare, regardless of whether it is being applied from the excursion fare or non-excursion round trip fare subroutine. In this case, an eligible entity in the excursion fare subroutine finding the BZ6

fare available passes to Node ZB7 where the fare is applied.

It is possible a passenger-entity eligible for one or more excursion fares may not find any applicable fares available. Any entity which passes through the excursion fare subroutine and fails the qualification or availability tests for the most expensive excursion fare is passed to an "Unavailable" counter (Node UNAV in Figure 2). This subroutine is accessible from all routes and is designed to provide another general measure of the applicability of discount fares. After being counted, the entity is returned to the non-excursion round trip fare subroutine, to the applicability/availability test for the fare next most expensive to the last tested in the excursion fare subroutine.

It must be noted that Route 6 (Hilo-Kahului) does not offer any excursion fares. An entity entering this route with its Attribute 5 set at "zero" (normally excursion eligible) is passed directly to the "Unavailable" counter and then returned to the first non-excursion round trip test.

The non-excursion round trip fare and one way fare subroutines operate almost identically to the excursion fare subroutine. The primary difference is that, since lead times and stay times are never a factor (at least for the ten routes included in the prototype model), the only attribute occasionally requiring testing is the day of departure. The fare availability variable COFULL is also used in these subroutines, but is never applicable to the excursion fare subroutines.

After an entity's market fare is determined and the route and system market fare totals updated, the entity passes to a routine to update the route and system totals for contract costs and full coach fare costs.

The increases in contract costs and full coach fare costs are standard; no attribute testing is required. For Route 7, one way passenger-entities pass through Node C07, where contract and full coach costs are increased an increment of the applicable one way fares. Round trip passenger-entities, regardless of whether or not they were excursion-eligible, pass through Node CR7 where costs are increased by twice the one way increment. After these statistics are updated, the entity is terminated.

#### Computerization

This section explains important segments of the SLAM II code used to implement the concepts introduced in the Model Development section. Portions of the code are included in the text to facilitate the discussion. A complete listing of the simulation code is found at Appendix A.

3. EQUIVALENCE/.9,RDTRIP/89660,VOLUME;
4. EQUIVALENCE/.25,FULL/.15,COFULL;

SLAM II EQUIVALENCE statements allow the programmer or user to assign, in one location near the beginning of the model, the value of a variable used only once or several times throughout the model. In line three, RDTRIP represents the proportion of entities that will be round trip passengers and VOLUME is the target number for annual passenger trips. The values for RDTRIP and VOLUME will be used to determine the entity interarrival times. RDTRIP is also used to assign Attribute 2 which will be a factor in determining the applicability of most fares.

In line four, FULL represents the probability a capacity controlled excursion fare will no longer be available; COFULL is the probability a

coach fare is sold out. These variables are used numerous times throughout the model.

```
5. TIMEST,XX(1),TOT CONTRACT CST;  
6. TIMEST,XX(2),TOT MARKET COST;  
7. TIMEST,XX(3),TOT COACH COST;  
. . . .  
26. TIMEST,XX(22),IND.PHL CASP COST;  
27. TIMEST,XX(23),IND.PHL MRKT COST;  
28. TIMEST,XX(24),IND.PHL COACH $;
```

The TIMEST statements allow for the collection and output of statistics on identified variables. In this model, they are used to track the expected contract fare costs, market fare costs, and full coach costs. There are three of these statements per route, plus three for the variables which will total the system-wide expenses.

Variables XX(1), XX(2), and XX(3) will be updated by every entity passing through the system, regardless of its route. Variables XX(22), XX(23), and XX(24) are examples of the variables which track costs for a single route, in this case the Indianapolis-Philadelphia route (Route 7) used in most of the examples of model development.

```
38. NETWORK;  
39. CREATE;  
40. ASSIGN,XX(49)=1+RDTRIP;  
41. ASSIGN,XX(50)=365*XX(49)/VOLUME;  
42. TERM;
```

Line 39 creates a single entity at time 0 (the default value). As it passes through lines 40 and 41 it computes the required mean interarrival time based on the RDTRIP and VOLUME parameters established through the EQUIVALENCE statements in lines three and four.

```
43. CREATE,EXPON(XX(50),1),1;  
44. ACT/1; ENTITY COUNT
```

Line 43 creates new entities based on the mean interarrival time

computed in lines 40 and 41. The "1" in the parenthesis specifies the interarrival times be generated using SLAM II random number stream 1. The "1" at the end of the line establishes time 1 as the time the first entity is created. The numbered activity in line 44 counts the number of entities created. Anything entered after the semicolon serves as the output label for the activity.

```
45. LDTM ASSIGN,II=RLOGN(10,10,2),ATRIB(1)=II,1;
46. ACT/2,,ATRIB(1).GT.90,LDTM;      REDO LEAD TM
47. ACT;
```

Line 45 generates entity lead times from random number stream 2, based on the lognormal distribution with a mean of 10 and standard deviation of 10. The integer global variable II takes the truncated integer form of the value and then stores it as Attribute 1 of the entity. The "1" at the end of the line limits the entity to one of the two activities in lines 46 and 47.

Line 46 tests for unreasonable lead times. If Attribute 1 is greater than 90, the entity is recycled to line 45 (Node LDTM) to calculate a new lead time. Because line 46 is a numbered activity, the number of recycled entities will be counted and printed. If the lead time is not excessive, the activity in line 47 allows the entity to continue to the next node.

```
48.      COLLECT,ATRIB(1),LEAD TIME,45/0/1;
49.      COLLECT,ATRIB(1),LEAD TIME WEEKS,9/6/7,1;
```

Lines 48 and 49 were designed to verify the distribution of lead times generated in line 45. The mean and standard deviation are calculated and histograms are printed by days up to 45 days (line 48) and by weeks up to nine weeks. The "1" at the end of line 49 allows the entity to take only one of the following activities:

```
50.      ACT/12,,RDTRIP,G01;      RD TRIP CNT
51.      ACT/11;                  ONE WAY TRIPS
52.      ASSIGN,ATRIB(2)=1,ATRIB(5)=1;
```

The uniform random number generator determines whether an entity will go to line 50 or 51, based on the value assigned to RDTRIP in the EQUIVALENCE statement of line 3. The entity is counted for the appropriate case. If the entity is assigned a round trip, it proceeds to Node G01. If it is a one way entity, line 52 sets Attributes 2 and 5 equal to "one".

```
53.  G01  GOON;
54.      ACT/4,,,15,SUN;      DEPRT SUNDAY
55.      ACT/5,,,3,MON;      MONDAY
56.      ACT/6,,,2,TUE;      TUESDAY
57.      ACT/7,,,15,WED;      WEDNESDAY
58.      ACT/8,,,1,THU;      THURSDAY
59.      ACT/9,,,05,FRI;      FRIDAY
60.      ACT/10,,,05,SAT;      SATURDAY
61.  SUN   ASSIGN,ATRIB(3)=7;
62.      ACT,,,G02;
```

Lines 54 through 60 assign the entity's departure day based on the uniform random number generator and the probabilities assigned to each day of the week. The activities were numbered to aid in verifying the performance of the model as it was being built. As the day is assigned, the entity is transferred to the node labeled for that day of the week. Attribute 3 is then coded according to the day assigned. An example for a Sunday departure is shown in line 61. After Attribute 3 is coded, the entity unconditionally goes to Node G02.

```
74.  G02  GOON,1;
75.      ACT,,ATRIB(2).EQ.1,RTS;
76.      ACT;
```

The GOON ("Go On") node specifies that an entity take only one of the following activities. If the entity's Attribute 2 is set at "one" (a one way entity), the entity may bypass the stay time assignment routine

and excursion fare tests and go directly to the route assignment routine at Node RTS. The activity on line 76 allows round trip entities to proceed to the stay time generation routine.

```
77. SSTM ASSIGN,II=RLOGN(10,14,3),ATTRIB(4)=II,1;
78.          ACT/3,,ATTRIB(4).GT.180,SSTM;      REDO STAY TM
79.          ACT;
```

Line 77 generates round trip entity stay times from random number stream 3, based on the lognormal distribution with a mean of 10 and standard deviation of 14. The integer global variable II takes the truncated integer form of the value and then stores it as Attribute 4 of the entity. The "1" at the end of the line limits the entity to one of the two activities in lines 78 and 79.

Line 78 tests for unreasonable stay times. If Attribute 4 is greater than 180, the entity is recycled to line 77 (Node SSTM) to calculate a new stay time. Because line 78 is a numbered activity, the number of recycled entities will be counted and printed. If the stay time is not excessive, the activity in line 79 allows the entity to continue to the next node.

```
80.          COLLECT,ATTRIB(4),STAY TIME,45/0/1;
81.          COLLECT,ATTRIB(4),STAY TIME WEEKS,14/6/7,1;
```

Lines 80 and 81 were designed to verify the distribution of stay times generated in line 77. The mean and standard deviation are calculated and histograms are printed by days up to 45 days (line 80) and by weeks up to 14 weeks. The "1" at the end of line 81 allows the entity to take only one of the following activities:

```
82.          ACT,,ATTRIB(1).GE.7,GO3;
83.          ACT/13;      INAD LEAD TM
84.          ASSIGN,ATTRIB(5)=1;
```

Line 82 begins the test of round trip entities to determine which

are not eligible for any excursion fare. Line 82 tests for adequate lead time (must be at least seven days for all excursion fares). If Attribute 1 is greater than or equal to seven, the lead time requirement is met and the entity proceeds to Node G03. Activity 13 on line 83 counts the number of entities that can not meet the lead time requirement. Line 84 sets Attribute 5 equal to "one" so the entity can efficiently bypass the excursion fare routine for the route it is assigned.

```
85. G03 GOON,1;
86. ACT/14,,ATRIB(3).EQ.7.AND.ATRIB(4).LT.7,G04; SUN DP SH ST
87. ACT/15,,ATRIB(3).EQ.1.AND.ATRIB(4).LT.6,G04; MON DP SH ST
88. ACT/16,,ATRIB(3).EQ.2.AND.ATRIB(4).LT.5,G04; TUE DP SH ST
89. ACT/17,,ATRIB(3).EQ.3.AND.ATRIB(4).LT.4,G04; WED DP SH ST
90. ACT/18,,ATRIB(3).EQ.4.AND.ATRIB(4).LT.3,G04; THU DP SH ST
91. ACT/19,,ATRIB(3).EQ.5.AND.ATRIB(4).LT.2,G04; FRI DP SH ST
92. ACT/20,,ATRIB(3).EQ.6.AND.ATRIB(4).LT.1,G04; SAT DP SH ST
93. ACT,,,G05;
94. G04 ASSIGN,ATRIB(5)=1;
95. ACT/21;           TOT SHT STAY
```

This series of statements determines whether the entity fulfills the minimum Sunday stay requirement. Each statement tests for two concurrent conditions based on the day of initial departure and the entity stay time. For example, a passenger-entity which initially departs on Sunday must stay at least seven days before returning to be eligible for an excursion fare. The statements test for the exceptions to the Sunday stay rule; that is, if a Sunday departee stays less than seven days, its Attribute 5 is set to "1" in line 94 and it is counted as a short stay entity in line 95.

An entity which passes all seven tests takes the activity in line 93 and bypasses the short stay counter. The activities in lines 86 through 92 were numbered to aid in verifying the performance of the model as it

was built.

```
96. G05 GOON,1;
97. ACT,,ATRIB(4).LE.60,G06;
98. ACT/22; EXDS STAY TM
99. ASSIGN,ATRIB(5)=1;
```

The final general test for excursion fare eligibility is to identify entities with excessive stay time. Line 97 tests Attribute 4 to detect if the entity's stay time is within the 60-day maximum required for excursion fares. If so, the entity passes to Node G06. If the entity's stay time exceeds 60 days, the activity in line 98 adds to the count of entities disqualified from excursion fares due to excessive stay time. The non-excursion fare switch (Attribute 5) is set in line 99.

```
100. G06 GOON,1;
101. ACT/24,,ATRIB(5).NE.1,RTS; POSS EXCURS
102. ACT/23; TOT DISQUALS
```

Because of the "1" in the GOON statement of line 100, an entity may take either the activity on line 101 or the one on line 102, but not both. Line 101 is for entities whose Attribute 5 is not "1". This activity counts the entities which have been found qualified for one or more excursion fares. The activity on line 102 counts the entities which, for one or more reasons, are not qualified for any excursion fare. In either case, the entity passes to the route selection routine at line 103 (Node RTS).

```
103. RTS GOON,1;
104. ACT/26,,,76981,RT1; BOS-WAS ENTS
105. ACT/28,,,00824,RT2; CHI-MSN ENTS
106. ACT/30,,,01047,RT3; CAE-SDF ENTS
107. ACT/32,,,00242,RT4; DFW-DSM ENTS
108. ACT/34,,,00626,RT5; DEN-PIT ENTS
109. ACT/36,,,00300,RT6; ITO-OGG ENTS
110. ACT/38,,,01393,RT7; IND-PHL ENTS
111. ACT/40,,,14223,RT8; MSP-WAS ENTS
112. ACT/42,,,02834,RT9; NYC-SYC ENTS
113. ACT/44,,,01530,RT10; SAN-WAS ENTS
```

Line 103 ensures that each entity is assigned only one route. The uniform number generator determines which of the routes is taken based on the probabilities specified for each activity. The activities are given alternating numbers so the intervening numbers can be used for trip counting activities. This facilitates the comparison of a route's entity count with its trip count, since the output statistics for activities are listed in numeric order.

The three-letter city codes, used to label each activity's output statistics, correspond with the codes used in the passenger tariff (27). After an entity is assigned its route, it is passed to the appropriate RT node to begin its fare selection routine.

As in describing the development of the model, Route 7 will be used to illustrate the coding of the fare determination routines.

```
675. RT7    ASSIGN,ATRIB(6)=7;
676.          ACT,,ATRIB(2).NE.1,C7A;
677.          ACT;
678. C7A    GOON;
679.          ACT/39;      IND-PHL TRIPS
680.          GOON;
681.          ACT,,,PXCT;
```

For each fare routine, Attribute 6 must be set to the entity's route number to enable the entity to return to its route after processing through either the PXCT or UNAV subroutines. For Route 7, this is accomplished in line 676.

To get a count of passenger trips over a particular route, a round trip entity must be split before it passes through the counter. In contrast to previous ASSIGN nodes, the RT7 ASSIGN node at line 675 does not limit an entity to one activity. For round trip entities (Attribute 2 has remained at its initial value of "zero"), the activities

on lines 676 and 677 must both be taken, thereby splitting the entity. Both parts of a split entity retain all the attributes of the original entity and the parts behave in exactly the same manner as a whole entity.

A one way entity does not meet the conditions for the activity on line 676, so it follows only the activity on line 677 to the node at line 678 (The initial "C" and the number "7" of the line 678 node label, and others to follow, identify it as part of the count subroutine for Route 7.). The activity on line 679 counts the trips; the split entity will count as two trips. The entity and trip counts will be listed together in the output since the entity count activity was numbered 38 and the trip count activity 39. Line 681 unconditionally passes the entity or entity parts to the PXCT subroutine.

```
1167.  PXCT  GOON;
1168.      ACT/46;      TOTAL PAX CT
1169.      GOON,1;
1170.      ACT,,ATRIB(6).EQ.1,C1B;
.
.
.
1176.      ACT,,ATRIB(6).EQ.7,C7B;
.
.
.
1179.      ACT,,ATRIB(6).EQ.10,C10B;
```

Line 1168 of the PXCT subroutine counts the total trips for the entire system of routes. Lines 1170 through 1179 test Attribute 6 until a match is found that will send the entity or entity parts back to the fare routine for its assigned route.

```
682.  C7B  GOON,1;
683.      ACT,,ATRIB(2).EQ.1,C7C;
684.      ACT;
685.      ACCUMULATE,2,2;
```

Of lines 683 and 684, only one activity can be taken. A one way

entity takes line 683 and skips to Node C7C. A round trip entity proceeds through line 684 to the ACCUMULATE node at line 685. As defined in this statement, a single entity (or entity part) can not pass through line 685. Instead, it must wait until another entity part also reaches the node. At that point, one part is destroyed and the other continues through the network, continuing to behave as the original complete entity.

```
686. C7C  GOON,1;  
687.      ACT,,ATRIB(5).EQ.1,NE7;  
688.      ACT;  
          :          :          :  
          :          :          :  
741. NE7  GOON,1;  
742.      ACT,,ATRIB(2).NE.1,ZA7;  
743.      ACT;
```

Having returned to its assigned route routine, the entity is now channeled to the appropriate fare determination subroutine. Line 687 tests Attribute 5 to determine if the entity has been found ineligible for all excursion fares. If so, it is passed to Node NE7 ("NE" stands for non-excursion). An entity found eligible for one or more excursion fares proceeds to line 689 to prepare for the first fare test, which will be described shortly.

Entities that arrive at Node NE7 must be tested to determine whether they are eligible for one way or round trip non-excursion fares. If Attribute 2 has not been reset to "one", the entity is a round trip entity and proceeds to Node ZA7 (Nodes for all non-excursion round trip fare routines begin with "Z" and end with the route number.). One way entities continue to line 930 for their fare determination subroutine (Nodes for the one way fare routines begin with "X").

Once the decision logic for the actual fare application is determined, the coding is relatively simple. The primary concerns are the attributes to be tested and the routing of the entity at each decision point. Since several examples of the logic were explained in the Model Development section, only two examples of fare application coding will be given here.

```
689.      GOON,1;
690.      ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RB7;
691.      ACT,,FULL,RA7;
692.      ACT;
```

In this model, the fare determination routines generally follow this rule: Test first for eligibility/applicability, then for availability. Line 690 displays the code for testing for an entity's ineligibility for Route 7's least expensive excursion fare, a E30 fare. An ineligible entity is passed to Node RB7 (All excursion fare nodes begin with "R" and the second letter is assigned according to the node's sequence in the flow chart.). Node RA7 is bypassed because it is a test for another E30 fare.

An entity that is eligible for the E30 fare may still find it full. If so, the entity will go to Node RA7 for the second E30 fare. An entity that avoids the activities on lines 690 and 691 has found an available fare for which it qualifies.

```
693.      ASSIGN,XX(23)=XX(23)+.000158,XX(2)=XX(2)+.000158;
694.      ACT,,CR7;
```

Being eligible and having found the E30 fare available, the entity now causes the time persistent variables XX(23) and XX(2), the accumulators for the route and system-wide market costs, to increase by the amount of the E30 fare, \$158. For ease in reading the output, all

time persistent variables are expressed in millions of dollars. Once the market cost variables have been updated, the entity passes to Node CR7 (Contract Costs, Round Trip).

All fare applications follow the form of lines 693 and 694. For one way fares, however, the entity is sent to Node CO7 (Contract Costs, One Way).

```
695. RA7    GOON,1;
696.          ACT,,ATRIB(3).GE.2.AND.ATRIB(3).LE.3,RB7;
697.          ACT,,FULL,RB7;
698.          ACT,,,RC7;
```

The second E30 fare is suffixed with an X23, so the departure day must be tested to determine eligibility. Ineligible entities are sent to Node RB7. Once an entity is found eligible, capacity is checked. Again, if there is no room at that fare, the entity passes to Node RB7.

Because there is another fare which is the same as the E30X23, eligible entities which find the E30X23 fare available are passed to the RC7 ASSIGN node, rather than assigning the market cost variables here.

The UNAV subroutine, as explained in the Model Development section, merely counts the number of entities that are eligible for one or more excursion fares but have found none available. Because UNAV is a counting process and the entities are returned to their route routines, the coding for this subroutine is very similar to that of the PXCT subroutine (page 54). The primary difference between the two is the UNAV subroutine returns the entity to the appropriate non-excursion round trip subroutine. The complete UNAV code is listed at lines 1180 through 1192 of Appendix A.

The CR and CO subroutines (for example, CR7 and CO7 for Route 7) update the the route and system variables for contract and coach fare

costs. The basic format is the same as that shown for the market costs (page 56), but the XX variable subscripts will be different. Because the CR subroutines are for round trip entities, the XX variables will be increased twice as much as they are for the CO subroutines. Once these variable have been updated, the entity's function in the simulation is complete, so the entity is terminated using the TERM statement. As an example, the complete CR and CO code for Route 7 is listed at lines 790 through 795 of Appendix A.

```
1193.      ENDNET;  
1194. INIT,0,365;
```

The ENDNET statement tells the SLAM II system that the description of the model network is complete. The length of the simulation is specified through the INIT statement in line 1194. This model starts simulating at time 0 and ends at time 365.

Model Verification. Verification is the process of ensuring the model behaves in the manner the builder intends (24:30). Verification of this prototype model was accomplished by incremental construction; careful line by line reading, comparing what was intended to be in the code with what was actually in the code; use of embedded error detection routines within SLAM II; and analysis of pilot run results.

By building the model in small increments, the source of detected errors could usually be found by checking only the code added since the preceding run.

The SLAM II Echo Report, printed automatically with each run, was helpful in verifying several of the input parameters. The intrinsic SLAM II error detection routines were vital for identifying syntax

errors, such as missing commas, missing node labels, and misplaced fields.

Analysis of output data was also important in verifying the model. Several data generating activities were included in the model, not primarily for analyzing the performance of the Contract Air Service Program, but to verify that the intended simulation logic and specified distribution functions were being followed.

At one point in the model building process, the source of a detected error could not be found by any of the previously described techniques. Specifically, one output report, from a run made after adding some of the fare determination subroutines, indicated several entities had been terminated at a node from which they were ineligible to proceed along any of its following activities. Because of the number of nodes which had been added at this iteration of the construction process, it was not readily apparent at which node the entities were being terminated. The source of the error was found through the SLAM II trace function, using the MONTR,TRACE statement (18:155,156).

Model Validation. Model validation is "the process of bringing to an acceptable level the user's confidence that any inference about a system derived from the simulation is correct" (24:29). It must be conceded that the validity of this model, as currently constructed, is questionable because of the number and nature of its assumptions. The objective of this research, however, was to build a prototype model which can be improved through further research which can implement statistically proven parameters.

#### IV. Analysis of Results

A sample of the model output, SLAM II Summary Report, is provided at Appendix B. Many of the statistics automatically included in all SLAM II Summary Reports are designed primarily for evaluating queuing models. Since the simulation developed in this study is not a queuing model, some of the report data is irrelevant. Important statistics will be identified in the following analysis.

The beginning of the Summary Report lists the current time (the time at which the statistics for output were collected) and the time the statistical arrays were last cleared. This data is important for verifying that the other statistics in the output are based on the intended simulation time. The sample report at Appendix B indicates the statistical arrays were cleared at Time 0 and the data collected at Time 365, providing 365 days of data just as intended.

The first table of the Summary Report, Statistics for Variables Based on Observation, displays the data gathered at the network's four COLLECT nodes. These nodes were included in the model, not to aid in analyzing the performance of the Contract Air Service Program, but to help in verifying the operation of the model.

The performance of the model's lead time and stay time generators can be partially verified by comparing the means and standard deviations of the times that passed through the COLLECT nodes with the parameters specified for the lognormal generators. In the sample run, the means and standard deviations were less than those specified for the generators in the model. An entity with a lead time greater than 90 days or a stay

time greater than 180 days is recycled through the appropriate generator before the attribute is recorded, so the collected lead times and stay times are not from a true lognormal distribution. Entities never reach the collect nodes with the larger times, so the means should be slightly less than the parameters specified for the lognormal generators. For the sample lead times and stay times the means were 9.36 and 9.35, respectively, compared to the 10.00 mean specified for the lognormal generator.

That entities are limited to lead times of 90 days and stay times of 180 days can be verified by checking the maximum value recorded for each variable.

The next block, Statistics for Time-Persistent Variables, is probably the most important of the Summary Report, because it provides all the cost data, the primary purpose of the model. Besides the variable label list on the left of the table, the only relevant columns are those for the maximum value and current value of each variable. Because each variable is a cost accumulator, it should reach its maximum value at its last incrementation before the simulation terminates; therefore, the maximum value and current value should always be equal.

Data in this table is grouped by route, with the system totals listed first. The effectiveness of the Contract Air Service Program can be evaluated by comparing the contract cost (labeled CASP CST) for any route or the whole system against the corresponding market cost (MRKT CST) or coach cost (COACH \$). In the sample run, \$7.16 million would have been spent through the Contract Air Service Program; the same travelers would have been charged a total of \$10.76 million, a \$3.6

million increase.

The final table, Regular Activity Statistics, lists the totals for the 46 counters placed throughout the model. The only relevant columns in this table are those for the activity labels and the entity counts. The model was designed so that related activities are usually grouped together in the output listing. For example, the counters for the seven departure days are listed consecutively as Activities 4 through 10.

Like the collect nodes, several of the entity counters were placed in the model, not for analyzing the Contract Air Service Program, but to aid in verifying the performance of the model. For example, the round trip count (Activity 12) is not particularly important except that, by comparing it to the total entity count (Activity 1), it helps to verify the performance of the round trip generator. In the sample run, 90.11 percent of the entities (42,420 of the 47,078 total) were round trip compared to the target of 90.00 percent.

Other entity counters can be very helpful in estimating the impacts of potential changes to the Contract Air Service Program. For example, the proportion of travelers who, on the open market, would be charged a non-excursion fare can be estimated by adding the counts for one way entities, round trip entities ineligible for excursion fares, and entities eligible for excursion fares not available (Activities 11, 23, and 25) and comparing the sum to the total entity count. In the sample run, 77.5 percent were charged a non-excursion fare.

The four histograms in the Summary Report, two each for lead times and stay times, were designed entirely to aid in verifying whether the times generated through the model were consistent with the intended

distributions. Because lognormal generators were used for both variables, the histograms and the relative frequency statistics provide better pictures of the data distribution than can be provided through the mean and standard deviation alone. The first histogram for each variable provides an expanded view of the distributions in their lower ranges where the frequencies are more dense.

An important test of the validity of a model is its consistency. This can best be determined by comparing results from multiple runs. The prototype model was run six times using antithetic random number seeds to reduce variances (6; 18:506-508). The Summary Report at Appendix B is from the second run.

A composite of several important statistics from the six runs is listed in Table V. (The "CASP" abbreviation in the first column label refers to the Contract Air Service Program.) All of the data was taken directly from the Summary Reports except for the last two columns. The "Unav/Poss Ratio" is the proportion of entities eligible for excursion fares that did not find any available. The ratio was found by dividing the entity count for Activity 25 by the count for Activity 24.

The "Non-Excur Ratio" represents the proportion of all entities forced to take a non-excursion fare. This was calculated by adding the counts for one way entities, round trip entities ineligible for excursion fares, and entities eligible for excursion fares not available (Activities 11, 23, and 25) and comparing the sum to the total entity count.

The data in Table V indicates the model is very consistent. The standard deviations for all variables are relatively low.

TABLE V  
Comparison of Sample Output Data

<u>Run</u>	<u>Total CASP Cost</u>	<u>Total Market Cost</u>	<u>Total Coach Cost</u>	<u>Total Entities</u>	<u>Total Trips</u>	<u>Poss Excur Fares</u>	<u>Unav Excur Fares</u>	<u>Unav/ Poss Ratio</u>	<u>Non- Excur Ratio</u>
1	7.12	10.72	17.81	46943	89126	11999	1422	.1185	.7747
2	7.16	10.76	17.88	47078	89498	12019	1420	.1181	.7749
3	7.14	10.74	17.86	46983	89191	12164	1395	.1147	.7708
4	7.14	10.74	17.89	47035	89424	12245	1496	.1222	.7715
5	7.12	10.67	17.79	46775	88956	12177	1387	.1139	.7693
6	7.19	10.80	17.98	47346	89980	12243	1447	.1182	.7720
Mean	7.15	10.74	17.87	47027	89363	12141	1428	.1176	.7722
S.D.	.027	.043	.067	188.1	361.7	107.8	39.6	.0030	.0022

## V. Conclusions and Recommendations

### Conclusions

The objective of this research has been to develop a prototype simulation model for evaluating the effectiveness of the Contract Air Service Program. The problems of incorporating government travel characteristics and the application of a cross section of passenger fares have been addressed. It has been shown that development of a comprehensive model is feasible and that information provided through such a model will be helpful to personnel who manage the Contract Air Service Program. The research questions from Chapter 1 provide a framework for discussing the conclusions drawn from this effort.

What routes should be incorporated in the prototype simulation model? Over what routes should the Contract Air Service Program fares and other air fares be compared? Because of the size of the Contract Air Service Program, it is unreasonable to expect any model to include the entire system of routes. A model incorporating a sample of routes can still provide adequate data for evaluating the program if the routes selected form a representative cross section of potential costs.

Air passenger transportation costs are a function of the interaction between passenger volumes and airline fares, so initial route selection should be representative of the wide spectrum of volume-fare combinations. It has been shown that neither low volumes nor low fares should be regarded as inherent indicators of routes with insignificant costs. Routes should be discarded from the sample only if their volume-fare interactions produce total costs which are insignificant.

relative to other routes.

What discount fares should be modeled and what restrictions apply?

Fares incorporated in the simulation should be representative of the entire range available, in terms of costs and restrictions. To aid in drawing comparisons between modeled routes, it is advantageous to include fare classes common to all modeled routes. Eligibility for excursion fares was found to be dependent on five categories of restrictions:

1. Round trip travel
2. Advance purchase (lead time)
3. Day of departure
4. Length of stay (minimums and maximums)

What government travel characteristics need to be included in the model? To test the applicability of excursion fares, the travel characteristics modeled must include the four categories of excursion fare restrictions. Successful implementation of a fully developed model will be dependent on incorporating empirically tested parameters for these travel characteristics, as well as for the forecasts of travel volume.

If the Contract Air Service Program were discontinued, would the savings achieved by travelers using discount fares be negated by other travelers who would be charged full coach fare? Of the four research questions, this is the most difficult to answer. Because the model developed in this study is only a prototype and many of the parameters are based on untested assumptions, any conclusions to be drawn concerning cost comparisons are questionable. However, the parameters were purposely chosen to favor the excursion fares and the output based on

those parameters reports the Contract Air Service Program is more economical than relying entirely on market forces. The answer to this question, then, would appear to be "Yes".

#### Recommendations for Further Research

The prototype model developed in this study demonstrates the feasibility of employing simulation as a means for evaluating the benefits of the Contract Air Service Program. The nature and number of assumptions employed in the prototype, however, limit the extent to which inferences can be drawn. Implementation of the following five recommendations will improve the model's validity.

First, a fully developed model must be built on a broader route structure. The prototype model is very limited in that, while the Contract Air Service Program covers over 1000 routes, it incorporates only ten. While it is unreasonable to expect that the entire system could or should be modeled, model validity can be improved with the introduction of more routes. Route selection for the prototype model was based on volume and fare considerations. Selection of routes for a fully developed model could be more meaningful if it were also designed to also ensure geographical representativeness.

The second recommendation is that better parameters for passenger volumes be specified. Parameters for total passenger volumes in the sample runs were applied in a historical context alone. That is, the runs attempted to merely recreate historical volumes of passengers. A more realistic approach for planning the future of the Contract Air Service Program is to develop forecasts for passenger volume that can be incorporated in the model. New volume parameters could be drawn from

system-wide trends or from a composite of forecasts of individual routes.

Next, reliable data concerning government travel characteristics must be gathered. Application of most discount fares is dependent on type of travel (round trip vs. one way), lead time, day of departure, and stay time. Empirically tested data on each of these characteristics, as it applies to government travelers, is crucial to the successful implementation of the model. Such data is available from most traffic management offices. Data should be gathered from a wide sample of bases, since travel patterns may differ significantly from base to base, depending on the missions supported.

The fourth area requiring further research is that of fare availability, particularly for capacity-controlled fares. In the prototype model, fare availability has been modeled using two constants, while it is likely dependent on several environmental factors. Data must be gathered concerning the relationship between the availability of discount fares and factors such as lead time, competition, and the number of flights offered.

Finally, an aspect which needs to be added to the model is the effect of changes in mission requirements. Most airlines assess a penalty fee for changing or cancelling a discount fare ticket. Because changes in mission requirements often affect travel plans, cancellation fees should be considered in the assessment of total costs. To accurately represent the expected market costs, data must be gathered concerning the extent to which travel plans change and the distribution of cancellation fees charged by the airlines.

Summary

The feasibility of employing simulation as a means for evaluating the benefits of the Contract Air Service Program has been demonstrated through this study. Further research and incorporation of the recommendations discussed in this chapter will enhance the validity of the model. Information provided through a fully developed model will be extremely helpful to the personnel at the Military Traffic Management Command and the General Services Administration responsible in making decisions concerning the Contract Air Service Program.

**Appendix A: Simulation Code Listing**

```
1 GEN,CAPT SHEPHERD,PAX FINAL 3, 9/2/86,5,,,,,,72;
2 LIMITS,,6,10;
3 EQUIVALENCE/.9, RDTRIP/89660, VOLUME;
4 EQUIVALENCE/.25, FULL/.15, COFULL;
5 TIMEST,XX(1), TOT CONTRACT CST;
6 TIMEST,XX(2), TOTL MARKET COST;
7 TIMEST,XX(3), TOTAL COACH COST;
8 TIMEST,XX(4), BOS.WAS CASP CST;
9 TIMEST,XX(5), BOS.WAS MRKT CST;
10 TIMEST,XX(6), BOS.WAS COACH $;
11 TIMEST,XX(7), CHI.MSN CASP CST;
12 TIMEST,XX(8), CHI.MSN MRKT CST;
13 TIMEST,XX(9), CHI.MSN COACH $;
14 TIMEST,XX(10), CAE.SDF CASP CST;
15 TIMEST,XX(11), CAE.SDF MRKT CST;
16 TIMEST,XX(12), CAE.SDF COACH $;
17 TIMEST,XX(13), DFW.DSM CASP CST;
18 TIMEST,XX(14), DFW.DSM MRKT CST;
19 TIMEST,XX(15), DFW.DSM COACH $;
20 TIMEST,XX(16), DEN.PIT CASP CST;
21 TIMEST,XX(17), DEN.PIT MRKT CST;
22 TIMEST,XX(18), DEN.PIT COACH $;
23 TIMEST,XX(19), ITO.OGG CASP CST;
24 TIMEST,XX(20), ITO.OGG MRKT CST;
25 TIMEST,XX(21), ITO.OGG COACH $;
26 TIMEST,XX(22), IND.PHL CASP CST;
27 TIMEST,XX(23), IND.PHL MRKT CST;
28 TIMEST,XX(24), IND.PHL COACH $;
29 TIMEST,XX(25), MSP.WAS CASP CST;
30 TIMEST,XX(26), MSP.WAS MRKT CST;
31 TIMEST,XX(27), MSP.WAS COACH $;
32 TIMEST,XX(28), NYC.SYC CASP CST;
33 TIMEST,XX(29), NYC.SYC MRKT CST;
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34 TIMEST,XX(30),NYC.SYC COACH $;
35 TIMEST,XX(31),SAN.WAS CASP CST;
36 TIMEST,XX(32),SAN.WAS MRKT CST;
37 TIMEST,XX(33),SAN.WAS COACH $;
38 NETWORK;
39      CREATE;
40      ASSIGN,XX(49)=1+RDTRIP;
41      ASSIGN,XX(50)=365*XX(49)/VOLUME;
42      TERM;
43      CREATE,EXPON(XX(50),1),1;
44      ACT/1;           ENTITY COUNT
45 LDTM  ASSIGN,II= RLOGN(10,10,2),ATRIB(1)=II,1;
46      ACT/2,,ATRIB(1).GT.90,LDTM;      REDO LEAD TM
47      ACT;
48      COLLECT,ATRIB(1),LEAD TIME,45/0/1;
49      COLLECT,ATRIB(1),LEAD TIME WEEKS,9/6/7,1;
50      ACT/12,,RDTRIP,G01;    RD TRIP CNT
51      ACT/11;           ONE WAY TRIPS
52      ASSIGN,ATRIB(2)=1,ATRIB(5)=1;
53 G01  GOON;
54      ACT/4,,,15,SUN;    DEPRT SUNDAY
55      ACT/5,,,30,MON;   MONDAY
56      ACT/6,,,2,TUE;    TUESDAY
57      ACT/7,,,15,WED;   WEDNESDAY
58      ACT/8,,,1,THU;   THURSDAY
59      ACT/9,,,05,FRI;  FRIDAY
60      ACT/10,,,05,SAT; SATURDAY
61 SUN   ASSIGN,ATRIB(3)=7;
62      ACT,,,G02;
63 MON   ASSIGN,ATRIB(3)=1;
64      ACT,,,G02;
65 TUE   ASSIGN,ATRIB(3)=2;
66      ACT,,,G02;
```

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67 WED ASSIGN,ATRIB(3)=3;
68      ACT,,,GO2;
69 THU ASSIGN,ATRIB(3)=4;
70      ACT,,,GO2;
71 FRI ASSIGN,ATRIB(3)=5;
72      ACT,,,GO2;
73 SAT ASSIGN,ATRIB(3)=6;
74 GO2 GOON,1;
75      ACT,,ATRIB(2).EQ.1,RTS;
76      ACT;
77 STTM ASSIGN,II= RLOGN(10,14,3),ATRIB(4)=II,1;
78      ACT/3,,ATRIB(4).GT.180,STTM;    REDO STAY TM
79      ACT;
80      COLLECT,ATRIB(4),STAY TIME,45/0/1;
81      COLLECT,ATRIB(4), STAY TIME WEEKS,14/6/7,1;
82      ACT,,ATRIB(1).GE.7,GO3;
83      ACT/13;      INAD LEAD TM
84      ASSICN,ATRIB(5)=1;
85 GO3 GOON,1;
86      ACT/14,,ATRIB(3).EQ.7.AND.ATRIB(4).LT.7,GO4;SUN SHST
87      ACT/15,,ATRIB(3).EQ.1.AND.ATRIB(4).LT.6,GO4;MON SHST
88      ACT/16,,ATRIB(3).EQ.2.AND.ATRIB(4).LT.5,GO4;TUE SHST
89      ACT/17,,ATRIB(3).EQ.3.AND.ATRIB(4).LT.4,GO4;WED SHST
90      ACT/18,,ATRIB(3).EQ.4.AND.ATRIB(4).LT.3,GO4;THU SHST
91      ACT/19,,ATRIB(3).EQ.5.AND.ATRIB(4).LT.2,GO4;FRI SHST
92      ACT/20,,ATRIB(3).EQ.6.AND.ATRIB(4).LT.1,GO4;SAT SHST
93      ACT,,,GO5;
94 GO4 ASSIGN,ATRIB(5)=1;
95      ACT/21;      TOT SHT STAY
96 GO5 GOON,1;
97      ACT,,ATRIB(4).LE.60,GO6;
98      ACT/22;      EXDS STAY TM
99      ASSIGN,ATRIB(5)=1;
100 GO6 GOON,1;
```

101       ACT/24,,ATRIB(5).NE.1,RTS;       POSS EXCURS  
102       ACT/23;       TOT DISQUALS  
103   RTS     GOON,1;  
104       ACT/26,,,76981,RT1;       BOS-WAS ENTS  
105       ACT/28,,,00824,RT2;       CHI-MSN ENTS  
106       ACT/30,,,01047,RT3;       CAE-SDF ENTS  
107       ACT/32,,,00242,RT4;       DFW-DSM ENTS  
108       ACT/34,,,00626,RT5;       DEN-PIT ENTS  
109       ACT/36,,,00300,RT6;       ITO-OGG ENTS  
110       ACT/38,,,01393,RT7;       IND-PHL ENTS  
111       ACT/40,,,14223,RT8;       MSP-WAS ENTS  
112       ACT/42,,,02834,RT9;       NYC-SYC ENTS  
113       ACT/44,,,01530,RT10;       SAN-WAS ENTS  
114   RT1     ASSIGN,ATRIB(6)=1;  
115       ACT,,ATRIB(2).NE.1,C1A;  
116       ACT;  
117   C1A     GOON;  
118       ACT/27;       BOS-WAS TRIPS  
119       GOON;  
120       ACT,,,PXCT;  
121   C1B     GOON,1;  
122       ACT,,ATRIB(2).EQ.1,C1C;  
123       ACT;  
124       ACCUMULATE,2,2;  
125   C1C     GOON,1;  
126       ACT,,ATRIB(5).EQ.1, NE1;  
127       ACT;  
128       GOON,1;  
129       ACT,,ATRIB(1).LT.30 .OR. ATRIB(4).GT.21,RA1;  
130       ACT,,FULL,RA1;  
131       ACT,,,RB1;  
132   RA1     GOON,1;  
133       ACT,,ATRIB(1).LT.7.OR.ATRIB(3).LT.6,RC1;

133.1 ACT,,ATRIB(4).GT.60,RC1;  
134 ACT,,FULL,RC1;  
135 ACT;  
136 RB1 ASSIGN,XX(5)=XX(5)+ .000118,XX(2)=XX(2)+.000118;  
137 ACT,,,CR1;  
138 RC1 GOON,1;  
139 ACT,,ATRIB(1).LT.21 .OR. ATRIB(4).GT.21,RE1;  
140 ACT,,FULL,RD1;  
141 ACT;  
142 ASSIGN,XX(5)=XX(5)+ .000138,XX(2)=XX(2)+.000138;  
143 ACT,,,CR1;  
144 RD1 GOON,1;  
145 ACT,,FULL,RE1;  
146 ACT;  
147 ASSIGN,XX(5)=XX(5)+ .000153,XX(2)=XX(2)+.000153;  
148 ACT,,,CR1;  
149 RE1 GOON,1;  
150 ACT,,ATRIB(3).LT.6, RF1; KZ67 RESTRICT  
151 ACT,,FULL,RF1;  
152 ACT,,,ZB1;  
153 RF1 GOON,1;  
154 ACT,,ATRIB(1).LT.7 .OR. ATRIB(4).GT.60,RH1;  
155 ACT,,FULL,RH1;  
156 ACT;  
157 GOON,1;  
158 ACT,,ATRIB(3).LT.6, RG1; BE70Z67(AL) RESTRICT  
159 ACT;  
160 ASSIGN,XX(5)=XX(5)+ .000164,XX(2)=XX(2)+.000164;  
161 ACT,,,CR1;  
162 RG1 ASSIGN,XX(5)=XX(5)+ .000178,XX(2)=XX(2)+.000178;  
163 ACT,,,CR1;  
164 RH1 GOON,1;  
165 ACT,,ATRIB(1).LT.14 .OR. ATRIB(4).GT.30,UNAV;  
166 ACT,,FULL,R11;

```
167      ACT;
168      ASSIGN,XX(5)=XX(5)+ .000193,XX(2)=XX(2)+.000193;
169      ACT,,,CR1;
170 RI1   GOON,1;
171      ACT,,FULL,UNAV;
172      ACT;
173      ASSIGN,XX(5)=XX(5)+ .000215,XX(2)=XX(2)+.000215;
174      ACT,,,CR1;
175 RX1   GOON,1;
176      ACT,,ATRIB(3).GE.6, ZD1;
177      ACT,,FULL,ZD1;
178      ACT,,,ZC1;
179 NE1   GOON,1;
180      ACT,,ATRIB(2).NE.1,ZA1;
181      ACT;
182      GOON,1;
183      ACT,,FULL,XB1;
184      ACT;
185      GOON,1;
186      ACT,,ATRIB(3).LT.6,XA1;
187      ACT;
188      ASSIGN,XX(5)=XX(5)+ .000079,XX(2)=XX(2)+.000079;
189      ACT,,,CO1;
190 XA1   ASSIGN,XX(5)=XX(5)+ .000109,XX(2)=XX(2)+.000109;
191      ACT,,,CO1;
192 XB1   GOON,1;
193      ACT,,COFULL,XC1;
194      ACT;
195      ASSIGN,XX(5)=XX(5)+ .000115,XX(2)=XX(2)+.000115;
196      ACT,,,CO1;
197 XC1   GOON,1;
198      ACT,,COFULL,XD1;
199      ACT;
200      ASSIGN,XX(5)=XX(5)+ .000156,XX(2)=XX(2)+.000156;
```

```
201      ACT,,,CO1;
202  XD1  GOON,1;
203      ACT,,COFULL,XE1;
204      ACT;
205      ASSIGN,XX(5)=XX(5)+ .000179,XX(2)=XX(2)+.000179;
206      ACT,,,CO1;
207  XE1  ASSIGN,XX(5)=XX(5)+ .000210,XX(2)=XX(2)+.000210;
208      ACT,,,CO1;
209  ZA1  GOON,1;
210      ACT,,FULL,ZC1;
211      ACT;
212      GOON,1;
213      ACT,,ATRIB(3).LT.6, ZC1;
214      ACT;
215  ZB1  ASSIGN,XX(5)=XX(5)+ .000158,XX(2)=XX(2)+.000158;
216      ACT,,,CR1;
217  ZC1  ASSIGN,XX(5)=XX(5)+ .000218,XX(2)=XX(2)+.000218;
218      ACT,,,CR1;
219  ZD1  GOON,1;
220      ACT,,COFULL,ZE1;
221      ACT;
222      ASSIGN,XX(5)=XX(5)+ .000230,XX(2)=XX(2)+.000230;
223      ACT,,,CR1;
224  ZE1  GOON,1;
225      ACT,,COFULL,ZF1;
226      ACT;
227      ASSIGN,XX(5)=XX(5)+ .000312,XX(2)=XX(2)+.000312;
228      ACT,,,CR1;
229  ZF1  GOON,1;
230      ACT,,COFULL,ZG1;
231      ACT;
232      ASSIGN,XX(5)=XX(5)+ .000358,XX(2)=XX(2)+.000358;
233      ACT,,,CR1;
```

```
234 ZG1    ASSIGN,XX(5)=XX(5)+ .000420,XX(2)=XX(2)+.000420;  
235          ACT,,,CR1;  
236 C01    ASSIGN,XX(4)=XX(4)+ .000064,XX(1)=XX(1)+.000064;  
237          ASSIGN,XX(6)=XX(6)+ .000179,XX(3)=XX(3)+.000179;  
238          TERM;  
239 CR1    ASSIGN,XX(4)=XX(4)+ .000128,XX(1)=XX(1)+.000128;  
240          ASSIGN,XX(6)=XX(6)+ .000358,XX(3)=XX(3)+.000358;  
241          TERM;  
242 RT2    ASSIGN,ATRIB(6)=2;  
243          ACT,,ATRIB(2).NE.1,C2A;  
244          ACT;  
245 C2A    GOON;  
246          ACT/29;      CHI-MSN TRIPS  
247          GOON;  
248          ACT,,,PXCT;  
249 C2B    GOON,1;  
250          ACT,,ATRIB(2).EQ.1,C2C;  
251          ACT;  
252          ACCUMULATE,2,2;  
253 C2C    GOON,1;  
254          ACT,,ATRIB(5).EQ.1,NE2;  
255          ACT;  
256          GOON,1;  
257          ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RA2;  
258          ACT,,FULL,RA2;  
259          ACT,,,RB2;  
260 RA2    GOON,1;  
261          ACT,,ATRIB(1).LT.14.OR.ATRIB(4).GT.30,RC2;  
262          ACT,,FULL,RC2;  
263          ACT;  
264 RB2    ASSIGN,XX(8)=XX(8)+.000108,XX(2)=XX(2)+.000108;  
265          ACT,,,CR2;  
266 RC2    GOON,1;
```

```
267      ACT,,ATTRIB(1).LT.7.OR.ATTRIB(4).GT.60,UNAV;
268      ACT,,FULL,UNAV;
269      ACT,,,ZB2;
270 NE2   GOON,1;
271      ACT,,ATTRIB(2).NE.1,ZA2;
272      ACT;
273      GOON,1;
274      ACT,,FULL,XA2;
275      ACT;
276      ASSIGN,XX(8)=XX(8)+.000089,XX(2)=XX(2)+.000089;
277      ACT,,,CO2;
278 XA2   GOON,1;
279      ACT,,COFULL,XB2;
280      ACT;
281      ASSIGN,XX(8)=XX(8)+.000120,XX(2)=XX(2)+.000120;
282      ACT,,,CO2;
283 XB2   ASSIGN,XX(8)=XX(8)+.000129,XX(2)=XX(2)+.000129;
284      ACT,,,CO2;
285 ZA2   GOON,1;
286      ACT,,FULL,ZC2;
287      ACT;
288 ZB2   ASSIGN,XX(8)=XX(8)+.000178,XX(2)=XX(2)+.000178;
289      ACT,,,CR2;
290 ZC2   GOON,1;
291      ACT,,COFULL,ZD2;
292      ACT;
293      ASSIGN,XX(8)=XX(8)+.000240,XX(2)=XX(2)+.000240;
294      ACT,,,CR2;
295 ZD2   ASSIGN,XX(8)=XX(8)+.000258,XX(2)=XX(2)+.000258;
296      ACT,,,CR2;
297 CO2   ASSIGN,XX(7)=XX(7)+.000082,XX(1)=XX(1)+.000082;
298      ASSIGN,XX(9)=XX(9)+.000120,XX(3)=XX(3)+.000120;
299      TERM;
300 CR2   ASSIGN,XX(7)=XX(7)+.000164,XX(1)=XX(1)+.000164;
```

```
301      ASSIGN,XX(9)=XX(9)+.000240,XX(3)=XX(3)+.000240;
302      TERM;
303  RT3  ASSIGN,ATTRIB(6)=3;
304      ACT,,ATTRIB(2).NE.1,C3A;
305      ACT;
306  C3A  GOON;
307      ACT/31;      CAE-SDF TRIPS
308      GOON;
309      ACT,,,PXCT;
310  C3B  GOON,1;
311      ACT,,ATTRIB(2).EQ.1,C3C;
312      ACT;
313      ACCUMULATE,2,2;
314  C3C  GOON,1;
315      ACT,,ATTRIB(5).EQ.1,NE3;
316      ACT;
317      GOON,1;
318      ACT,,ATTRIB(1).LT.30.OR.ATTRIB(4).GT.21,RA3;
319      ACT,,FULL,RA3;
320      ACT;
321      GOON,1;
322      ACT,,ATTRIB(3).LT.2.OR.ATTRIB(3).GT.3,RB3;
323      ACT;
324      ASSIGN,XX(11)=XX(11)+.000133,XX(2)=XX(2)+.000133;
325      ACT,,,CR3;
326  RA3  GOON,1;
327      ACT,,ATTRIB(1).LT.21.OR.ATTRIB(4).GT.21,RD3;
328      ACT,,FULL,RD3;
329      ACT;
330      GOON,1;
331      ACT,,ATTRIB(3).LT.2.OR.ATTRIB(3).GT.3,RC3;
332      ACT;
333  RB3  ASSIGN,XX(11)=XX(11)+.000153,XX(2)=XX(2)+.000153;
```

334       ACT,,,CR3;  
335 RC3     ASSIGN,XX(11)=XX(11)+.000173,XX(2)=XX(2)+.000173;  
336       ACT,,,CR3;  
337 RD3     GOON,1;  
338       ACT,,ATRIB(3).NE.6,RF3;  
339       ACT,,FULL,RE3;  
340       ACT,,,ZB3;  
341 RE3     GOON,1;  
342       ACT,,FULL,RF3;  
343       ACT,,,ZD3;  
344 RF3     GOON,1;  
345       ACT,,ATRIB(1).LT.14.OR.ATRIB(4).GT.30,RG3;  
346       ACT,,FULL,RG3;  
347       ACT,,,ZD3;  
348 RG3     GOON,1;  
349       ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,UNAV;  
350       ACT,,FULL,UNAV;  
351       ACT;  
352       ASSIGN,XX(11)=XX(11)+.000312,XX(2)=XX(2)+.000312;  
353       ACT,,,CR3;  
354 NE3     GOON,1;  
355       ACT,,ATRIB(2).NE.1,ZA3;  
356       ACT;  
357       GOON,1;  
358       ACT,,ATRIB(3).NE.6,XB3;  
359       ACT,,FULL,XA3;  
360       ACT;  
361       ASSIGN,XX(11)=XX(11)+.000098,XX(2)=XX(2)+.000098;  
362       ACT,,,CO3;  
363 XA3     GOON,1;  
364       ACT,,FULL,XB3;  
365       ACT;  
366       ASSIGN,XX(11)=XX(11)+.000117,XX(2)=XX(2)+.000117;

```
367      ACT,,,C03;
368  XB3    ASSIGN,XX(11)=XX(11)+.000195,XX(2)=XX(2)+.000195;
369      ACT,,,C03;
370  ZA3    GOON,1;
371      ACT,,ATRIB(3).NE.6,ZE3;
372      ACT,,FULL,ZC3;
373      ACT;
374  ZB3    ASSIGN,XX(11)=XX(11)+.000196,XX(2)=XX(2)+.000196;
375      ACT,,,CR3;
376  ZC3    GOON,1;
377      ACT,,FULL,ZE3;
378      ACT;
379  ZD3    ASSIGN,XX(11)=XX(11)+.000234,XX(2)=XX(2)+.000234;
380      ACT,,,CR3;
381  ZE3    ASSIGN,XX(11)=XX(11)+.000390,XX(2)=XX(2)+.000390;
382      ACT,,,CR3;
383  C03    ASSIGN,XX(10)=XX(10)+.000116,XX(1)=XX(1)+.000116;
384      ASSIGN,XX(12)=XX(12)+.000195,XX(3)=XX(3)+.000195;
385      TERM;
386  CR3    ASSIGN,XX(10)=XX(10)+.000232,XX(1)=XX(1)+.000232;
387      ASSIGN,XX(12)=XX(12)+.000390,XX(3)=XX(3)+.000390;
388      TERM;
389  RT4    ASSIGN,ATRIB(6)=4;
390      ACT,,ATRIB(2).NE.1,C4A;
391      ACT;
392  C4A    GOON;
393      ACT/33;      DFW-DSM TRIPS
394      GOON;
395      ACT,,,PXCT;
396  C4B    GOON,1;
397      ACT,,ATRIB(2).EQ.1,C4C;
398      ACT;
399      ACCUMULATE,2,2;
400  C4C    GOON,1;
```

```
401      ACT,,ATRIB(5).EQ.1,NE4;
402      ACT;
403      GOON,1;
404      ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RA4;
405      ACT,,FULL,RA4;
406      ACT;
407      GOON,1;
408      ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RB4;
409      ACT;
410      ASSIGN,XX(14)=XX(14)+.000158,XX(2)=XX(2)+.000158;
411      ACT,,,CR4;
412      RA4  GOON,1;
413      ACT,,ATRIB(1).LT.21.OR.ATRIB(4).GT.21,RD4;
414      ACT,,FULL,RD4;
415      ACT;
416      GOON,1;
417      ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RC4;
418      ACT;
419      RB4  ASSIGN,XX(14)=XX(14)+.000178,XX(2)=XX(2)+.000178;
420      ACT,,,CR4;
421      RC4  ASSIGN,XX(14)=XX(14)+.000198,XX(2)=XX(2)+.000198;
422      ACT,,,CR4;
423      RD4  GOON,1;
424      ACT,,ATRIB(1).LT.14.OR.ATRIB(4).GT.30,RF4;
425      ACT,,FULL,RE4;
426      ACT;
427      ASSIGN,XX(14)=XX(14)+.000260,XX(2)=XX(2)+.000260;
428      ACT,,,CR4;
429      RE4  GOON,1;
430      ACT,,FULL,RF4;
431      ACT;
432      ASSIGN,XX(14)=XX(14)+.000280,XX(2)=XX(2)+.000280;
433      ACT,,,CR4;
```

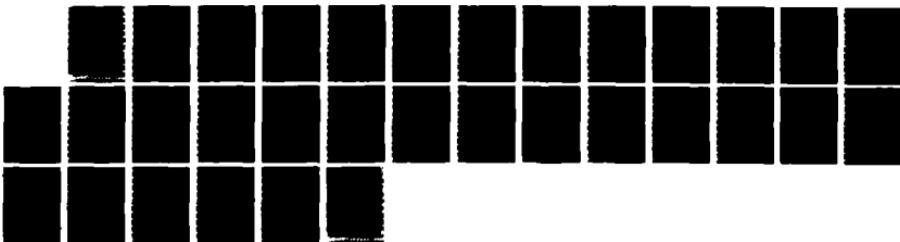
434 RF4 GOON,1;  
435 ACT,,FULL,RG4;  
436 ACT,,,ZB4;  
437 RG4 GOON,1;  
438 ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,UNAV;  
439 ACT,,FULL,UNAV;  
440 ACT,,,ZD4;  
441 NE4 GOON,1;  
442 ACT,,ATRIB(2).NE.1,ZA4;  
443 ACT;  
444 GOON,1;  
445 ACT,,FULL,XA4;  
446 ACT;  
447 ASSIGN,XX(14)=XX(14)+.000150,XX(2)=XX(2)+.000150;  
448 ACT,,,CO4;  
449 XA4 GOON,1;  
450 ACT,,FULL,XB4;  
451 ACT;  
452 ASSIGN,XX(14)=XX(14)+.000200,XX(2)=XX(2)+.000200;  
453 ACT,,,CO4;  
454 XB4 GOON,1;  
455 ACT,,COFULL,XC4;  
456 ACT;  
457 ASSIGN,XX(14)=XX(14)+.000250,XX(2)=XX(2)+.000250;  
458 ACT,,,CO4;  
459 XC4 GOON,1;  
460 ACT,,COFULL,XD4;  
461 ACT;  
462 ASSIGN,XX(14)=XX(14)+.000290,XX(2)=XX(2)+.000290;  
463 ACT,,,CO4;  
464 XD4 ASSIGN,XX(14)=XX(14)+.000330,XX(2)=XX(2)+.000330;  
465 ACT,,,CO4;  
466 ZA4 GOON,1;

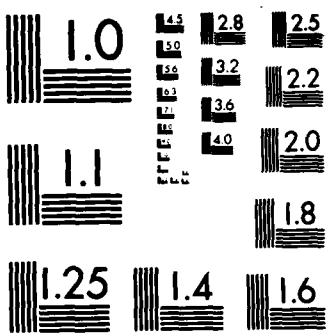
467       ACT,,FULL,ZC4;  
468       ACT;  
469 ZB4     ASSIGN,XX(14)=XX(14)+.000300,XX(2)=XX(2)+.000300;  
470       ACT,,,CR4;  
471 ZC4     GOON,1;  
472       ACT,,FULL,ZE4;  
473       ACT;  
474 ZD4     ASSIGN,XX(14)=XX(14)+.000460,XX(2)=XX(2)+.000460;  
475       ACT,,,CR4;  
476 ZE4     GOON,1;  
477       ACT,,COFULL,ZF4;  
478       ACT;  
479       ASSIGN,XX(14)=XX(14)+.000500,XX(2)=XX(2)+.000500;  
480       ACT,,,CR4;  
481 ZF4     GOON,1;  
482       ACT,,COFULL,ZG4;  
483       ACT;  
484       ASSIGN,XX(14)=XX(14)+.000580,XX(2)=XX(2)+.000580;  
485       ACT,,,CR4;  
486 ZG4     ASSIGN,XX(14)=XX(14)+.000660,XX(2)=XX(2)+.000660;  
487       ACT,,,CR4;  
488 CO4     ASSIGN,XX(13)=XX(13)+.000129,XX(1)=XX(1)+.000129;  
489       ASSIGN,XX(15)=XX(15)+.000250,XX(3)=XX(3)+.000250;  
490       TERM;  
491 CR4     ASSIGN,XX(13)=XX(13)+.000258,XX(1)=XX(1)+.000258;  
492       ASSIGN,XX(15)=XX(15)+.000500,XX(3)=XX(3)+.000500;  
493       TERM;  
494 RT5     ASSIGN,ATRIB(6)=5;  
495       ACT,,ATRIB(2).NE.1,C5A;  
496       ACT;  
497 C5A     GOON;  
498       ACT/35;     DEN-PIT TRIPS  
499       GOON;  
500       ACT,,,PXCT;

```
501 C5B GOON,1;
502      ACT,,ATRIB(2).EQ.1,C5C;
503      ACT;
504      ACCUMULATE,2,2;
505 C5C GOON,1;
506      ACT,,ATRIB(5).EQ.1,NES;
507      ACT;
508      GOON,1;
509      ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RA5;
510      ACT,,FULL,RA5;
511      ACT;
512      GOON,1;
513      ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RB5;
514      ACT;
515      ASSIGN,XX(17)=XX(17)+.000218,XX(2)=XX(2)+.000218;
516      ACT,,,CR5;
517 RA5 GOON,1;
518      ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,RC5;
519      ACT,,FULL,RC5;
520      ACT;
521 RB5 ASSIGN,XX(17)=XX(17)+.000238,XX(2)=XX(2)+.000238;
522      ACT,,,CR5;
523 RC5 GOON,1;
524      ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RD5;
525      ACT,,ATRIB(3).GE.2.AND.ATRIB(3).LE.3,RD5;
526      ACT,,FULL,RD5;
527      ACT,,,RE5;
528 RD5 GOON,1;
529      ACT,,ATRIB(1).LT.21.OR.ATRIB(4).GT.21,RH5;
530      ACT,,FULL,RG5;
531      ACT;
532      GOON,1;
533      ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RF5;
```

```
534      ACT;
535 RE5    ASSIGN,XX(17)=XX(17)+.000258,XX(2)=XX(2)+.000258;
536      ACT,,,CR5;
537 RF5    ASSIGN,XX(17)=XX(17)+.000278,XX(2)=XX(2)+.000278;
538      ACT,,,CR5;
539 RG5    GOON,1;
540      ACT,,ATRIB(3).GE.2.AND.ATRIB(3).LE.3,RH5;
541      ACT,,FULL,RH5;
542      ACT;
543      ASSIGN,XX(17)=XX(17)+.000298,XX(2)=XX(2)+.000298;
544      ACT,,,CR5;
545 RH5    GOON,1;
546      ACT,,FULL,RI5;
547      ACT,,,ZB5;
548 RI5    GOON,1;
549      ACT,,FULL,RJ5;
550      ACT,,,ZD5;
551 RJ5    GOON,1;
552      ACT,,ATRIB(1).LT.14.OR.ATRIB(4).GT.30,RL5;
553      ACT,,FULL,RK5;
554      ACT;
555      ASSIGN,XX(17)=XX(17)+.000418,XX(2)=XX(2)+.000418;
556      ACT,,,CR5;
557 RK5    GOON,1;
558      ACT,,FULL,RL5;
559      ACT;
560      ASSIGN,XX(17)=XX(17)+.000444,XX(2)=XX(2)+.000444;
561      ACT,,,CR5;
562 RL5    GOON,1;
563      ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,RM5;
564      ACT,,FULL,RM5;
565      ACT,,,ZF5;
566 RM5    GOON,1;
```

AD-A174 625 A SLAM MODEL OF DOMESTIC AIRLINE PASSENGER FARES AND 2/2  
THE CONTRACT AIR SER (U) AIR FORCE INST OF TECH  
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST D A SHEPHERD  
UNCLASSIFIED SEP 86 AFIT/GLM/LSM/865-72 F/G 14/1 NL





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

567       ACT,,FULL,RN5;  
568       ACT,,,ZF5;  
569 RN5     GOON,1;  
570       ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,UNAV;  
571       ACT,,FULL,UNAV;  
572       ACT;  
573       ASSIGN,XX(17)=XX(17)+.000592,XX(2)=XX(2)+.000592;  
574       ACT,,,CR5;  
575 NES     GOON,1;  
576       ACT,,ATRIB(2).NE.1,ZA5;  
577       ACT;  
578       GOON,1;  
579       ACT,,FULL,XA5;  
580       ACT;  
581       ASSIGN,XX(17)=XX(17)+.000180,XX(2)=XX(2)+.000180;  
582       ACT,,,CO5;  
583 XA5     GOON,1;  
584       ACT,,FULL,XB5;  
585       ACT;  
586       ASSIGN,XX(17)=XX(17)+.000190,XX(2)=XX(2)+.000190;  
587       ACT,,,CO5;  
588 XB5     GOON,1;  
589       ACT,,FULL,XC5;  
590       ACT;  
591       ASSIGN,XX(17)=XX(17)+.000230,XX(2)=XX(2)+.000230;  
592       ACT,,,CO5;  
593 XC5     GOON,1;  
594       ACT,,COFULL,XD5;  
595       ACT;  
596       ASSIGN,XX(17)=XX(17)+.000348,XX(2)=XX(2)+.000348;  
597       ACT,,,CO5;  
598 XD5     ASSIGN,XX(17)=XX(17)+.000370,XX(2)=XX(2)+.000370;  
599       ACT,,,CO5;  
600 ZA5     GOON,1;

601       ACT,,FULL,ZC5;  
602       ACT;  
603 ZB5     ASSIGN,XX(17)=XX(17)+.000360,XX(2)=XX(2)+.000360;  
604       ACT,,,CR5;  
605 ZC5     GOON,1;  
606       ACT,,FULL,ZE5;  
607       ACT;  
608 ZD5     ASSIGN,XX(17)=XX(17)+.000380,XX(2)=XX(2)+.000380;  
609       ACT,,,CR5;  
610 ZE5     GOON,1;  
611       ACT,,FULL,ZG5;  
612       ACT;  
613 ZF5     ASSIGN,XX(17)=XX(17)+.000460,XX(2)=XX(2)+.000460;  
614       ACT,,,CR5;  
615 ZG5     GOON,1;  
616       ACT,,COFULL,ZH5;  
617       ACT;  
618       ASSIGN,XX(17)=XX(17)+.000696,XX(2)=XX(2)+.000696;  
619       ACT,,,CR5;  
620 ZH5     ASSIGN,XX(17)=XX(17)+.000740,XX(2)=XX(2)+.000740;  
621       ACT,,,CR5;  
622 C05     ASSIGN,XX(16)=XX(16)+.000242,XX(1)=XX(1)+.000242;  
623       ASSIGN,XX(18)=XX(18)+.000348,XX(3)=XX(3)+.000348;  
624       TERM;  
625 CR5     ASSIGN,XX(16)=XX(16)+.000484,XX(1)=XX(1)+.000484;  
626       ASSIGN,XX(18)=XX(18)+.000696,XX(3)=XX(3)+.000696;  
627       TERM;  
628 RT6     ASSIGN,ATRIB(6)=6;  
629       ACT,,ATRIB(2).NE.1,C6A;  
630       ACT;  
631 C6A     GOON;  
632       ACT/37;      ITO-OGG TRIPS  
633       GOON;

634           ACT,,,PXCT;  
635 C6B     GOON,1;  
636           ACT,,ATTRIB(2).EQ.1,C6C;  
637           ACT;  
638           ACCUMULATE,2,2;  
639 C6C     GOON,1;  
640           ACT,,ATTRIB(5).EQ.1,NE6;  
641           ACT,,,UNAV;  
642 NE6     GOON,1;  
643           ACT,,ATTRIB(2).NE.1,ZA6;  
644           ACT;  
645           GOON,1;  
646           ACT,,FULL,XA6;  
647           ACT;  
648           ASSIGN,XX(20)=XX(20)+.000039,XX(2)=XX(2)+.000039;  
649           ACT,,,CO6;  
650 XA6     GOON,1;  
651           ACT,,FULL,XB6;  
652           ACT;  
653           ASSIGN,XX(20)=XX(20)+.000045,XX(2)=XX(2)+.000045;  
654           ACT,,,CO6;  
655 XB6     ASSIGN,XX(20)=XX(20)+.000069,XX(2)=XX(2)+.000069;  
656           ACT,,,CO6;  
657 ZA6     GOON,1;  
658           ACT,,FULL,ZB6;  
659           ACT;  
660           ASSIGN,XX(20)=XX(20)+.000078,XX(2)=XX(2)+.000078;  
661           ACT,,,CR6;  
662 ZB6     GOON,1;  
663           ACT,,FULL,ZC6;  
664           ACT;  
665           ASSIGN,XX(20)=XX(20)+.000090,XX(2)=XX(2)+.000090;  
666           ACT,,,CR6;

667 ZC6 ASSIGN,XX(20)=XX(20)+.000138,XX(2)=XX(2)+.000138;  
668 ACT,,,CR6;  
669 C06 ASSIGN,XX(19)=XX(19)+.000028,XX(1)=XX(1)+.000028;  
670 ASSIGN,XX(21)=XX(21)+.000069,XX(3)=XX(3)+.000069;  
671 TERM;  
672 CR6 ASSIGN,XX(19)=XX(19)+.000056,XX(1)=XX(1)+.000056;  
673 ASSIGN,XX(21)=XX(21)+.000138,XX(3)=XX(3)+.000138;  
674 TERM;  
675 RT7 ASSIGN,ATRIB(6)=7;  
676 ACT,,ATRIB(2).NE.1,C7A;  
677 ACT;  
678 C7A GOON;  
679 ACT/39; IND-PHL TRIPS  
680 GOON;  
681 ACT,,,PXCT;  
682 C7B GOON,1;  
683 ACT,,ATRIB(2).EQ.1,C7C;  
684 ACT;  
685 ACCUMULATE,2,2;  
686 C7C GOON,1;  
687 ACT,,ATRIB(5).EQ.1,NE7;  
688 ACT;  
689 GOON,1;  
690 ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RB7;  
691 ACT,,FULL,RA7;  
692 ACT;  
693 ASSIGN,XX(23)=XX(23)+.000158,XX(2)=XX(2)+.000158;  
694 ACT,,,CR7;  
695 RA7 GOON,1;  
696 ACT,,ATRIB(3).GE.2.AND.ATRIB(3).LE.3,RB7;  
697 ACT,,FULL,RB7;  
698 ACT,,,RC7;  
699 RB7 GOON,1;  
700 ACT,,ATRIB(1).LT.21.OR.ATRIB(4).GT.21,RE7;

701       ACT,,FULL,RE7;  
702       ACT;  
703       GOON,1;  
704       ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RD7;  
705       ACT;  
706    RC7    ASSIGN,XX(23)=XX(23)+.000178,XX(2)=XX(2)+.000178;  
707       ACT,,,CR7;  
708    RD7    ASSIGN,XX(23)=XX(23)+.000198,XX(2)=XX(2)+.000198;  
709       ACT,,,CR7;  
710    RE7    GOON,1;  
711       ACT,,ATRIB(3).NE.6,RG7;  
712       ACT,,FULL,RF7;  
713       ACT,,,ZB7;  
714    RF7    GOON,1;  
715       ACT,,FULL,RG7;  
716       ACT,,,ZD7;  
717    RG7    GOON,1;  
718       ACT,,ATRIB(1).LT.14.OR.ATRIB(4).GT.30,RJ7;  
719       ACT,,FULL,RH7;  
720       ACT;  
721       ASSIGN,XX(23)=XX(23)+.000258,XX(2)=XX(2)+.000258;  
722       ACT,,,CR7;  
723    RH7    GOON,1;  
724       ACT,,FULL,RI7;  
725       ACT;  
726       ASSIGN,XX(23)=XX(23)+.000270,XX(2)=XX(2)+.000270;  
727       ACT,,,CR7;  
728    RI7    GOON,1;  
729       ACT,,FULL,RJ7;  
730       ACT,,,ZF7;  
731    RJ7    GOON,1;  
732       ACT,,ATRIB(3).NE.6,RK7;  
733       ACT,,FULL,RK7;

734        ACT,,,ZF7;  
735 RK7     GOON,1;  
736        ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,UNAV;  
737        ACT,,FULL,UNAV;  
738        ACT;  
739        ASSIGN,XX(23)=XX(23)+.000376,XX(2)=XX(2)+.000376;  
740        ACT,,,CR7;  
741 NE7     GOON,1;  
742        ACT,,ATRIB(2).NE.1,ZA7;  
743        ACT;  
744        GOON,1;  
745        ACT,,ATRIB(3).NE.6,XC7;  
746        ACT,,FULL,XA7;  
747        ACT;  
748        ASSIGN,XX(23)=XX(23)+.000109,XX(2)=XX(2)+.000109;  
749        ACT,,,CO7;  
750 XA7     GOON,1;  
751        ACT,,FULL,XB7;  
752        ACT;  
753        ASSIGN,XX(23)=XX(23)+.000118,XX(2)=XX(2)+.000118;  
754        ACT,,,CO7;  
755 XB7     GOON,1;  
756        ACT,,FULL,XC7;  
757        ACT;  
758        ASSIGN,XX(23)=XX(23)+.000141,XX(2)=XX(2)+.000141;  
759        ACT,,,CO7;  
760 XC7     GOON,1;  
761        ACT,,COFULL,XD7;  
762        ACT;  
763        ASSIGN,XX(23)=XX(23)+.000235,XX(2)=XX(2)+.000235;  
764        ACT,,,CO7;  
765 XD7     ASSIGN,XX(23)=XX(23)+.000250,XX(2)=XX(2)+.000250;  
766        ACT,,,CO7;

767 ZA7 GOON,1;  
768 ACT,,ATRIB(3).NE.1,ZG7;  
769 ACT,,FULL,ZC7;  
770 ACT;  
771 ZB7 ASSIGN,XX(23)=XX(23)+.000218,XX(2)=XX(2)+.000218;  
772 ACT,,,CR7;  
773 ZC7 GOON,1;  
774 ACT,,FULL,ZE7;  
775 ACT;  
776 ZD7 ASSIGN,XX(23)=XX(23)+.000236,XX(2)=XX(2)+.000236;  
777 ACT,,,CR7;  
778 ZE7 GOON,1;  
779 ACT,,FULL,ZG7;  
780 ACT;  
781 ZF7 ASSIGN,XX(23)=XX(23)+.000282,XX(2)=XX(2)+.000282;  
782 ACT,,,CR7;  
783 ZG7 GOON,1;  
784 ACT,,COFULL,ZH7;  
785 ACT;  
786 ASSIGN,XX(23)=XX(23)+.000470,XX(2)=XX(2)+.000470;  
787 ACT,,,CR7;  
788 ZH7 ASSIGN,XX(23)=XX(23)+.000500,XX(2)=XX(2)+.000500;  
789 ACT,,,CR7;  
790 C07 ASSIGN,XX(22)=XX(22)+.000103,XX(1)=XX(1)+.000103;  
791 ASSIGN,XX(24)=XX(24)+.000235,XX(3)=XX(3)+.000235;  
792 TERM;  
793 CR7 ASSIGN,XX(22)=XX(22)+.000206,XX(3)=XX(3)+.000206;  
794 ASSIGN,XX(24)=XX(24)+.000470,XX(3)=XX(3)+.000470;  
795 TERM;  
796 RT8 ASSIGN,ATRIB(6)=8;  
797 ACT,,ATRIB(2).NE.1,C8A;  
798 ACT;  
799 C8A GOON;  
800 ACT/41; MSP-WAS TRIPS

```
801      GOON;
802      ACT,,,PXCT;
803 C8B   GOON,1;
804      ACT,,ATRIB(2).EQ.1,C8C;
805      ACT;
806      ACCUMULATE,2,2;
807 C8C   GOON,1;
808      ACT,,ATRIB(5).EQ.1,NE8;
809      ACT;
810      GOON,1;
811      ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RA8;
812      ACT,,FULL,RA8;
813      ACT;
814      GOON,1;
815      ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RB8;
816      ACT;
817      ASSIGN,XX(26)=XX(26)+.000178,XX(2)=XX(2)+.000178;
818      ACT,,,CR8;
819 RA8   GOON,1;
820      ACT,,ATRIB(1).LT.21.OR.ATRIB(4).GT.21,RD8;
821      ACT,,FULL,RD8;
822      ACT;
823      GOON,1;
824      ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RC8;
825      ACT;
826 RB8   ASSIGN,XX(26)=XX(26)+.000198,XX(2)=XX(2)+.000198;
827      ACT,,,CR8;
828 RC8   ASSIGN,XX(26)=XX(26)+.000218,XX(2)=XX(2)+.000218;
829      ACT,,,CR8;
830 RD8   GOON,1;
831      ACT,,ATRIB(1).LT.14.OR.ATRIB(4).GT.30,RF8;
832      ACT,,FULL,RE8;
833      ACT;
```

834           ASSIGN,XX(26)=XX(26)+.000298,XX(2)=XX(2)+.000298;  
835           ACT,,,CR8;  
836 RE8       GOON,1;  
837           ACT,,FULL,RF8;  
838           ACT;  
839           ASSIGN,XX(26)=XX(26)+.000348,XX(2)=XX(2)+.000348;  
840           ACT,,,CR8;  
841 RF8       GOON,1;  
842           ACT,,FULL,RG8;  
843           ACT,,,ZB8;  
844 RG8       GOON,1;  
845           ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,UNAV;  
846           ACT,,FULL,UNAV;  
847           ACT;  
848           ASSIGN,XX(26)=XX(26)+.000464,XX(2)=XX(2)+.000464;  
849           ACT,,,CR8;  
850 NE8       GOON,1;  
851           ACT,,ATRIB(2).NE.1,ZA8;  
852           ACT;  
853           GOON,1;  
854           ACT,,COFULL,XA8;  
855           ACT;  
856           ASSIGN,XX(26)=XX(26)+.000210,XX(2)=XX(2)+.000210;  
857           ACT,,,CO8;  
858 XA8       ASSIGN,XX(26)=XX(26)+.000290,XX(2)=XX(2)+.000290;  
859           ACT,,,CO8;  
860 ZA8       GOON,1;  
861           ACT,,COFULL,ZC8;  
862           ACT;  
863 ZB8       ASSIGN,XX(26)=XX(26)+.000420,XX(2)=XX(2)+.000420;  
864           ACT,,,CR8;  
865 ZC8       ASSIGN,XX(26)=XX(26)+.000580,XX(2)=XX(2)+.000580;  
866           ACT,,,CR8;

867 C08 ASSIGN,XX(25)=XX(25)+.000152,XX(1)=XX(1)+.000152;  
868 ASSIGN,XX(27)=XX(27)+.000290,XX(3)=XX(3)+.000290;  
869 TERM;  
870 CR8 ASSIGN,XX(25)=XX(25)+.000304,XX(1)=XX(1)+.000304;  
871 ASSIGN,XX(27)=XX(27)+.000580,XX(3)=XX(3)+.000580;  
872 TERM;  
873 RT9 ASSIGN,ATRIB(6)=9;  
874 ACT,,ATRIB(2).NE.1,C9A;  
875 ACT;  
876 C9A GOON;  
877 ACT/43; NYC-SYC TRIPS  
878 GOON;  
879 ACT,,,PXCT;  
880 C9B GOON,1;  
881 ACT,,ATRIB(2).EQ.1,C9C;  
882 ACT;  
883 ACCUMULATE,2,2;  
884 C9C GOON,1;  
885 ACT,,ATRIB(5).EQ.1,NE9;  
886 ACT;  
887 GOON,1;  
888 ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RA9;  
889 ACT,,FULL,RA9;  
890 ACT;  
891 ASSIGN,XX(29)=XX(29)+.000098,XX(2)=XX(2)+.000098;  
892 ACT,,,CR9;  
893 RA9 GOON,1;  
894 ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,RB9;  
895 ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RB9;  
896 ACT,,FULL,RB9;  
897 ACT;  
898 ASSIGN,XX(29)=XX(29)+.000108,XX(2)=XX(2)+.000108;  
899 ACT,,,CR9;  
900 RB9 GOON,1;

901       ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RC9;  
902       ACT,,FULL,RC9;  
903       ACT,,,ZB9;  
904 RC9     GOON,1;  
905       ACT,,ATRIB(1).LT.21.OR.ATRIB(4).GT.21,RD9;  
906       ACT,,FULL,RD9;  
907       ACT,,,ZB9;  
908 RD9     GOON,1;  
909       ACT,,ATRIB(3).NE.6,RE9;  
910       ACT,,FULL,RE9;  
911       ACT,,,ZB9;  
912 RE9     GOON,1;  
913       ACT,,ATRIB(1).LT.21.OR.ATRIB(4).GT.21,RF9;  
914       ACT,,FULL,RF9;  
915       ACT;  
916       ASSIGN,XX(29)=XX(29)+.000138,XX(2)=XX(2)+.000138;  
917       ACT,,,CR9;  
918 RF9     GOON,1;  
919       ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,UNAV;  
920       ACT,,ATRIB(3).GE.2.AND.ATRIB(3).LE.3,UNAV;  
921       ACT,,FULL,UNAV;  
922       ACT,,,ZD9;  
923 RX9     GOON,1;  
924       ACT,,ATRIB(3).EQ.6,ZC9;  
925       ACT,,,ZI9;  
926 NE9     GOON,1;  
927       ACT,,ATRIB(2).NE.1,ZA9;  
928       ACT;  
929       GOON,1;  
930       ACT,,ATRIB(3).NE.6,XF9;  
931       ACT,,FULL,XA9;  
932       ACT;  
933       ASSIGN,XX(29)=XX(29)+.000059,XX(2)=XX(2)+.000059;

934           ACT,,,C09;  
935 XA9       GOON,1;  
936        ACT,,FULL,XB9;  
937        ACT;  
938        ASSIGN,XX(29)=XX(29)+.000074,XX(2)=XX(2)+.000074;  
939        ACT,,,C09;  
940 XB9       GOON,1;  
941        ACT,,FULL,XC9;  
942        ACT;  
943        ASSIGN,XX(29)=XX(29)+.000075,XX(2)=XX(2)+.000075;  
944        ACT,,,C09;  
945 XC9       GOON,1;  
946        ACT,,FULL,XD9;  
947        ACT;  
948        ASSIGN,XX(29)=XX(29)+.000079,XX(2)=XX(2)+.000079;  
949        ACT,,,C09;  
950 XD9       GOON,1;  
951        ACT,,FULL,XE9;  
952        ACT;  
953        ASSIGN,XX(29)=XX(29)+.000092,XX(2)=XX(2)+.000092;  
954        ACT,,,C09;  
955 XE9       GOON,1;  
956        ACT,,FULL,XF9;  
957        ACT;  
958        ASSIGN,XX(29)=XX(29)+.000094,XX(2)=XX(2)+.000094;  
959        ACT,,,C09;  
960 XF9       GOON,1;  
961        ACT,,COFULL,XG9;  
962        ACT;  
963        ASSIGN,XX(29)=XX(29)+.000104,XX(2)=XX(2)+.000104;  
964        ACT,,,C09;  
965 XG9       ASSIGN,XX(29)=XX(29)+.000130,XX(2)=XX(2)+.000130;  
966        ACT,,,C09;

967 ZA9 GOON,1;  
968 ACT,,ATTRIB(3).NE.6,ZI9;  
969 ACT,,FULL,ZC9;  
970 ACT;  
971 ZB9 ASSIGN,XX(29)=XX(29)+.000118,XX(2)=XX(2)+.000118;  
972 ACT,,,CR9;  
973 ZC9 GOON,1;  
974 ACT,,FULL,ZE9;  
975 ACT;  
976 ZD9 ASSIGN,XX(29)=XX(29)+.000148,XX(2)=XX(2)+.000148;  
977 ACT,,,CR9;  
978 ZE9 GOON,1;  
979 ACT,,FULL,ZF9;  
980 ACT;  
981 ASSIGN,XX(29)=XX(29)+.000150,XX(2)=XX(2)+.000150;  
982 ACT,,,CR9;  
983 ZF9 GOON,1;  
984 ACT,,FULL,ZG9;  
985 ACT;  
986 ASSIGN,XX(29)=XX(29)+.000158,XX(2)=XX(2)+.000158;  
987 ACT,,,CR9;  
988 ZG9 GOON,1;  
989 ACT,,FULL,ZH9;  
990 ACT;  
991 ASSIGN,XX(29)=XX(29)+.000184,XX(2)=XX(2)+.000184;  
992 ACT,,,CR9;  
993 ZH9 GOON,1;  
994 ACT,,FULL,ZI9;  
995 ACT;  
996 ASSIGN,XX(29)=XX(29)+.000188,XX(2)=XX(2)+.000188;  
997 ACT,,,CR9;  
998 ZI9 GOON,1;  
999 ACT,,COFULL,ZJ9;  
1000 ACT;

1001       ASSIGN,XX(29)=XX(29)+.000208,XX(2)=XX(2)+.000208;  
1002       ACT,,,CR9;  
1003 ZJ9      ASSIGN,XX(29)=XX(29)+.000260,XX(2)=XX(2)+.000260;  
1004       ACT,,,CR9;  
1005 C09      ASSIGN,XX(28)=XX(28)+.000059,XX(1)=XX(1)+.000059;  
1006       ASSIGN,XX(30)=XX(30)+.000104,XX(3)=XX(3)+.000104;  
1007       TERM;  
1008 CR9      ASSIGN,XX(28)=XX(28)+.000118,XX(1)=XX(1)+.000118;  
1009       ASSIGN,XX(30)=XX(30)+.000208,XX(3)=XX(3)+.000208;  
1010       TERM;  
1011 RT10     ASSIGN,ATRIB(6)=10;  
1012       ACT,,ATRIB(2).NE.1,C10A;  
1013       ACT;  
1014 C10A     GOON;  
1015       ACT/45;     SAN-WAS TRIPS  
1016       GOON;  
1017       ACT,,,PXCT;  
1018 C10B     GOON,1;  
1019       ACT,,ATRIB(2).EQ.1,C10C;  
1020       ACT;  
1021       ACCUMULATE,2,2;  
1022 C10C     GOON,1;  
1023       ACT,,ATRIB(5).EQ.1,NE10;  
1024       ACT;  
1025       GOON,1;  
1026       ACT,,ATRIB(1).LT.30.OR.ATRIB(4).GT.21,RC10;  
1027       ACT,,FULL,RB10;  
1028       ACT;  
1029       GOON,1;  
1030       ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RA10;  
1031       ACT;  
1032       ASSIGN,XX(32)=XX(32)+.000278,XX(2)=XX(2)+.000278;  
1033       ACT,,,CR10;

```
1034 RA10 ASSIGN,XX(32)=XX(32)+.000298,XX(2)=XX(2)+.000298;
1035          ACT,,,CR10;
1036 RB10 GOON,1;
1037          ACT,,ATRIB(3).GE.2.AND.ATRIB(3).LE.3,RC10;
1038          ACT,,FULL,RC10;
1039          ACT,,,RD10;
1040 RC10 GOON,1;
1041          ACT,,ATRIB(1).LT.21.OR.ATRIB(4).GT.21,RG10;
1042          ACT,,FULL,RF10;
1043          ACT;
1044          GOON,1;
1045          ACT,,ATRIB(3).LT.2.OR.ATRIB(3).GT.3,RE10;
1046          ACT;
1047 RD10 ASSIGN,XX(32)=XX(32)+.000318,XX(2)=XX(2)+.000318;
1048          ACT,,,CR10;
1049 RE10 ASSIGN,XX(32)=XX(32)+.000338,XX(2)=XX(2)+.000338;
1050          ACT,,,CR10;
1051 RF10 GOON,1;
1052          ACT,,ATRIB(3).GE.2.AND.ATRIB(3).LE.3,RG10;
1053          ACT,,FULL,RG10;
1054          ACT;
1055          ASSIGN,XX(32)=XX(32)+.000358,XX(2)=XX(2)+.000358;
1056          ACT,,,CR10;
1057 RG10 GOON,1;
1058          ACT,,ATRIB(1).LT.14.OR.ATRIB(4).GT.30,RH10;
1059          ACT,,FULL,RH10;
1060          ACT;
1061          ASSIGN,XX(32)=XX(32)+.000378,XX(2)=XX(2)+.000378;
1062          ACT,,,CR10;
1063 RH10 GOON,1;
1064          ACT,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,RJ10;
1065          ACT,,FULL,RI10;
1066          ACT;
```

1067        ASSIGN,XX(32)=XX(32)+.000460,XX(2)=XX(2)+.000460;  
1068        ACT,,,CR10;  
1069 RI10    GOON,1;  
1070        ACT,,,FULL,RJ10;  
1071        ACT,,,ZB10;  
1072 RJ10    GOON,1;  
1073        ACT,,,FULL,RK10;  
1074        ACT,,,ZB10;  
1075 RK10    GOON,1;  
1076        ACT,,,FULL,RL10;  
1077        ACT,,,ZE10;  
1078 RL10    GOON,1;  
1079        ACT,,,COFULL,RM10;  
1080        ACT,,,ZE10;  
1081 RM10    GOON,1;  
1082        ACT,,,ATRIB(1).LT.14.OR.ATRIB(4).GT.30,RO10;  
1083        ACT,,,FULL,RN10;  
1084        ACT;  
1085        ASSIGN,XX(32)=XX(32)+.000548,XX(2)=XX(2)+.000548;  
1086        ACT,,,CR10;  
1087 RN10    GOON,1;  
1088        ACT,,,FULL,RO10;  
1089        ACT;  
1090        ASSIGN,XX(32)=XX(32)+.000576,XX(2)=XX(2)+.000576;  
1091        ACT,,,CR10;  
1092 RO10    GOON,1;  
1093        ACT,,,ATRIB(1).LT.7.OR.ATRIB(4).GT.60,UNAV;  
1094        ACT,,,FULL,UNAV;  
1095        ACT;  
1096        ASSIGN,XX(32)=XX(32)+.000731,XX(2)=XX(2)+.000731;  
1097        ACT,,,CR10;  
1098 NE10    GOON,1;  
1099        ACT,,,ATRIB(2).NE.1,ZA10;  
1100        ACT;

```
1101      GOON,1;
1102      ACT,,FULL,XA10;
1103      ACT;
1104      ASSIGN,XX(32)=XX(32)+.000240,XX(2)=XX(2)+.000240;
1105      ACT,,,CO10;
1106  XA10  GOON,1;
1107      ACT,,FULL,XB10;
1108      ACT,,,XC10;
1109  XB10  GOON,1;
1110      ACT,,COFULL,XD10;
1111      ACT;
1112  XC10  ASSIGN,XX(32)=XX(32)+.000250,XX(2)=XX(2)+.000250;
1113      ACT,,,CO10;
1114  XD10  GOON,1;
1115      ACT,,COFULL,XE10;
1116      ACT;
1117      ASSIGN,XX(32)=XX(32)+.000411,XX(2)=XX(2)+.000411;
1118      ACT,,,CO10;
1119  XE10  GOON,1;
1120      ACT,,COFULL,XF10;
1121      ACT;
1122      ASSIGN,XX(32)=XX(32)+.000457,XX(2)=XX(2)+.000457;
1123      ACT,,,CO10;
1124  XF10  GOON,1;
1125      ACT,,COFULL,XG10;
1126      ACT;
1127      ASSIGN,XX(32)=XX(32)+.000480,XX(2)=XX(2)+.000480;
1128      ACT,,,CO10;
1129  XG10  ASSIGN,XX(32)=XX(32)+.000490,XX(2)=XX(2)+.000490;
1130      ACT,,,CO10;
1131  ZA10  GOON,1;
1132      ACT,,FULL,ZC10;
1133      ACT;
```

```
1134 ZB10 ASSIGN,XX(32)=XX(32)+.000480,XX(2)=XX(2)+.000480;
1135      ACT,,,CR10;
1136 ZC10 GOON,1;
1137      ACT,,FULL,ZD10;
1138      ACT,,,ZE10;
1139 ZD10 GOON,1;
1140      ACT,,COFULL,ZF10;
1141      ACT;
1142 ZE10 ASSIGN,XX(32)=XX(32)+.000500,XX(2)=XX(2)+.000500;
1143      ACT,,,CR10;
1144 ZF10 GOON,1;
1145      ACT,,COFULL,ZG10;
1146      ACT;
1147 ASSIGN,XX(32)=XX(32)+.000822,XX(2)=XX(2)+.000822;
1148      ACT,,,CR10;
1149 ZG10 GOON,1;
1150      ACT,,COFULL,ZH10;
1151      ACT;
1152 ASSIGN,XX(32)=XX(32)+.000914,XX(2)=XX(2)+.000914;
1153      ACT,,,CR10;
1154 ZH10 GOON,1;
1155      ACT,,COFULL,ZI10;
1156      ACT;
1157 ASSIGN,XX(32)=XX(32)+.000960,XX(2)=XX(2)+.000960;
1158      ACT,,,CR10;
1159 ZI10 ASSIGN,XX(32)=XX(32)+.000980,XX(2)=XX(2)+.000980;
1160      ACT,,,CR10;
1161 CO10 ASSIGN,XX(31)=XX(31)+.000224,XX(1)=XX(1)+.000224;
1162 ASSIGN,XX(33)=XX(33)+.000457,XX(3)=XX(3)+.000457;
1163 TERM;
1164 CR10 ASSIGN,XX(31)=XX(31)+.000448,XX(1)=XX(1)+.000448;
1165 ASSIGN,XX(33)=XX(33)+.000914,XX(3)=XX(3)+.000914;
1166 TERM;
```

1167 PXCT GOON;  
1168 ACT/46; TOTAL PAX CT  
1169 GOON,1;  
1170 ACT,,ATRIB(6).EQ.1,C1B;  
1171 ACT,,ATRIB(6).EQ.2,C2B;  
1172 ACT,,ATRIB(6).EQ.3,C3B;  
1173 ACT,,ATRIB(6).EQ.4,C4B;  
1174 ACT,,ATRIB(6).EQ.5,C5B;  
1175 ACT,,ATRIB(6).EQ.6,C6B;  
1176 ACT,,ATRIB(6).EQ.7,C7B;  
1177 ACT,,ATRIB(6).EQ.8,C8B;  
1178 ACT,,ATRIB(6).EQ.9,C9B;  
1179 ACT,,ATRIB(6).EQ.10,C10B;  
1180 UNAV GOON;  
1181 ACT/25; UNAV EXCURS  
1182 GOON,1;  
1183 ACT,,ATRIB(6).EQ.1,RX1;  
1184 ACT,,ATRIB(6).EQ.2,ZA2;  
1185 ACT,,ATRIB(6).EQ.3,ZE3;  
1186 ACT,,ATRIB(6).EQ.4,ZC4;  
1187 ACT,,ATRIB(6).EQ.5,ZG5;  
1188 ACT,,ATRIB(6).EQ.6,ZA6;  
1189 ACT,,ATRIB(6).EQ.7,ZG7;  
1190 ACT,,ATRIB(6).EQ.8,ZC8;  
1191 ACT,,ATRIB(6).EQ.9,RX9;  
1192 ACT,,ATRIB(6).EQ.10,ZF10;  
1193 ENDNET;  
1194 INIT,0,365;

**Appendix B: Sample Output Report**

**SLAM II SUMMARY REPORT**

**SIMULATION PROJECT PAX FINAL 3**

**BY CAPT SHEPHERD**

**DATE 9/ 2/1986**

**RUN NUMBER 2 OF 5**

**CURRENT TIME 0.3650E+03  
STATISTICAL ARRAYS CLEARED AT TIME 0.0000E+00**

**\*\*STATISTICS FOR VARIABLES BASED ON OBSERVATION\*\***

	<b>MEAN VALUE</b>	<b>STANDARD DEVIATION</b>	<b>COEFF. OF VARIATION</b>	<b>MINIMUM VALUE</b>	<b>MAXIMUM VALUE</b>	<b>NO. OF OBS</b>
LEAD TIME	0.936E+01	0.928E+01	0.992E+00	0.000E+00	0.900E+02	****
LEAD TIME WEEKS	0.936E+01	0.928E+01	0.992E+00	0.000E+00	0.900E+02	****
STAY TIME	0.935E+01	0.128E+02	0.137E+01	0.000E+00	0.180E+03	****
STAY TIME WEEKS	0.935E+01	0.128E+02	0.137E+01	0.000E+00	0.180E+03	****

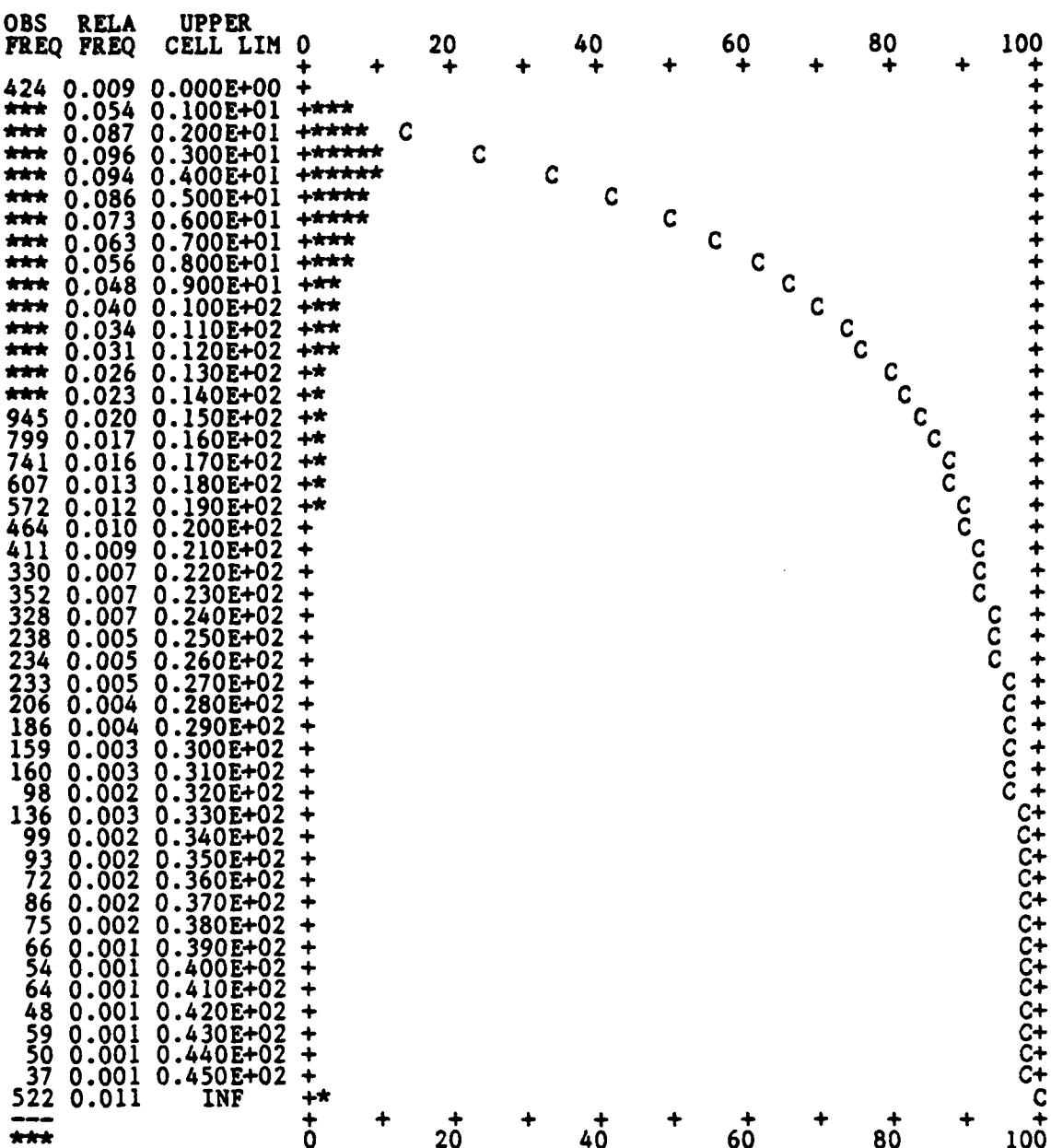
**\*\*STATISTICS FOR TIME-PERSISTENT VARIABLES\*\***

	<b>MEAN VALUE</b>	<b>STANDARD DEVIATION</b>	<b>MINIMUM VALUE</b>	<b>MAXIMUM VALUE</b>	<b>TIME INTERVAL</b>	<b>CURRENT VALUE</b>
TOT CONTRACT CST	3.580	2.067	0.00	7.16	365.000	7.16
TOTL MARKET COST	5.377	3.107	0.00	10.76	365.000	10.76
TOTAL COACH COST	8.940	5.161	0.00	17.88	365.000	17.88
BOS.WAS CASP CST	2.200	1.269	0.00	4.40	365.000	4.40
BOS.WAS MRKT CST	3.410	1.968	0.00	6.83	365.000	6.83
BOS.WAS COACH \$	6.152	3.549	0.00	12.31	365.000	12.31
CHI.MSN CASP CST	0.028	0.017	0.00	0.06	365.000	0.06
CHI.MSN MRKT CST	0.032	0.019	0.00	0.06	365.000	0.06
CHI.MSN COACH \$	0.041	0.024	0.00	0.08	365.000	0.08
CAE.SDF CASP CST	0.057	0.034	0.00	0.11	365.000	0.11
CAE.SDF MRKT CST	0.088	0.052	0.00	0.18	365.000	0.18
CAE.SDF COACH \$	0.096	0.057	0.00	0.19	365.000	0.19
DFW.DSM CASP CST	0.012	0.007	0.00	0.02	365.000	0.02
DFW.DSM MRKT CST	0.015	0.010	0.00	0.03	365.000	0.03
DFW.DSM COACH \$	0.023	0.014	0.00	0.05	365.000	0.05
DEN.PIT CASP CST	0.072	0.040	0.00	0.14	365.000	0.14
DEN.PIT MRKT CST	0.052	0.029	0.00	0.10	365.000	0.10
DEN.PIT COACH \$	0.104	0.058	0.00	0.20	365.000	0.20
ITO.OGG CASP CST	0.004	0.002	0.00	0.01	365.000	0.01
ITO.OGG MRKT CST	0.006	0.003	0.00	0.01	365.000	0.01
ITO.OGG COACH \$	0.010	0.005	0.00	0.02	365.000	0.02
IND.PHL CASP CST	0.065	0.037	0.00	0.13	365.000	0.13
IND.PHL MRKT CST	0.119	0.069	0.00	0.24	365.000	0.24
IND.PHL COACH \$	0.147	0.085	0.00	0.29	365.000	0.29
MSP.WAS CASP CST	0.976	0.566	0.00	1.95	365.000	1.95
MSP.WAS MRKT CST	1.369	0.795	0.00	2.74	365.000	2.74
MSP.WAS COACH \$	1.862	1.079	0.00	3.72	365.000	3.72
NYC.SYC CASP CST	0.076	0.043	0.00	0.15	365.000	0.15
NYC.SYC MRKT CST	0.126	0.071	0.00	0.25	365.000	0.25
NYC.SYC COACH \$	0.135	0.076	0.00	0.26	365.000	0.26
SAN.WAS CASP CST	0.152	0.087	0.00	0.31	365.000	0.31
SAN.WAS MRKT CST	0.161	0.092	0.00	0.32	365.000	0.32
SAN.WAS COACH \$	0.311	0.178	0.00	0.63	365.000	0.63

\*\*REGULAR ACTIVITY STATISTICS\*\*

ACTIVITY INDEX/LABEL	AVERAGE UTILIZATION	STANDARD DEVIATION	MAXIMUM UTIL	CURRENT UTIL	ENTITY COUNT
1 ENTITY COUNT	0.0000	0.0000	1	0	47078
2 REDO LEAD TM	0.0000	0.0000	1	0	50
3 REDO STAY TM	0.0000	0.0000	1	0	18
4 DEPRT SUNDAY	0.0000	0.0000	1	0	7057
5 MONDAY	0.0000	0.0000	1	0	14118
6 TUESDAY	0.0000	0.0000	1	0	9319
7 WEDNESDAY	0.0000	0.0000	1	0	7084
8 THURSDAY	0.0000	0.0000	1	0	4701
9 FRIDAY	0.0000	0.0000	1	0	2400
10 SATURDAY	0.0000	0.0000	1	0	2399
11 ONE WAY TRIP	0.0000	0.0000	1	0	4658
12 RD TRIP CNT	0.0000	0.0000	1	0	42420
13 INAD LEAD TM	0.0000	0.0000	1	0	21192
14 SUN DP SH ST	0.0000	0.0000	1	0	3716
15 MON DP SH ST	0.0000	0.0000	1	0	6477
16 TUE DP SH ST	0.0000	0.0000	1	0	3728
17 WED DP SH ST	0.0000	0.0000	1	0	2302
18 THU DP SH ST	0.0000	0.0000	1	0	1089
19 FRI DP SH ST	0.0000	0.0000	1	0	351
20 SAT DP SH ST	0.0000	0.0000	1	0	99
21 TOT SHT STAY	0.0000	0.0000	1	0	17762
22 EXDS STAY TM	0.0000	0.0000	1	0	461
23 TOT DISQUALS	0.0000	0.0000	1	0	30401
24 POSS EXCURS	0.0000	0.0000	1	0	12019
25 UNAV EXCURS	0.0000	0.0000	1	0	1420
26 BOS-WAS ENTS	0.0000	0.0000	1	0	36227
27 BOS-WAS TRIP	0.0000	0.0000	1	0	68792
28 CHI-MSN ENTS	0.0000	0.0000	1	0	365
29 CHI-MSN TRIP	0.0000	0.0000	1	0	693
30 CAE-SDF ENTS	0.0000	0.0000	1	0	511
31 CAE-SDF TRIP	0.0000	0.0000	1	0	988
32 DFW-DSM ENTS	0.0000	0.0000	1	0	101
33 DFW-DSM TRIP	0.0000	0.0000	1	0	191
34 DEN-PIT ENTS	0.0000	0.0000	1	0	307
35 DEN-PIT TRIP	0.0000	0.0000	1	0	583
36 ITO-OGG ENTS	0.0000	0.0000	1	0	143
37 ITO-OGG TRIP	0.0000	0.0000	1	0	272
38 IND-PHL ENTS	0.0000	0.0000	1	0	650
39 IND-PHL TRIP	0.0000	0.0000	1	0	1242
40 MSP-WAS ENTS	0.0000	0.0000	1	0	6730
41 MSP-WAS TRIP	0.0000	0.0000	1	0	12837
42 NYC-SYC ENTS	0.0000	0.0000	1	0	1328
43 NYC-SYC TRIP	0.0000	0.0000	1	0	2529
44 SAN-WAS ENTS	0.0000	0.0000	1	0	716
45 SAN-WAS TRIP	0.0000	0.0000	1	0	1371
46 TOTAL PAX CT	0.0000	0.0000	1	0	89498

\*\*HISTOGRAM NUMBER 1\*\*  
LEAD TIME



\*\*STATISTICS FOR VARIABLES BASED ON OBSERVATION\*\*

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO. OF OBS
LEAD TIME	0.936E+01	0.928E+01	0.992E+00	0.000E+00	0.900E+02	****

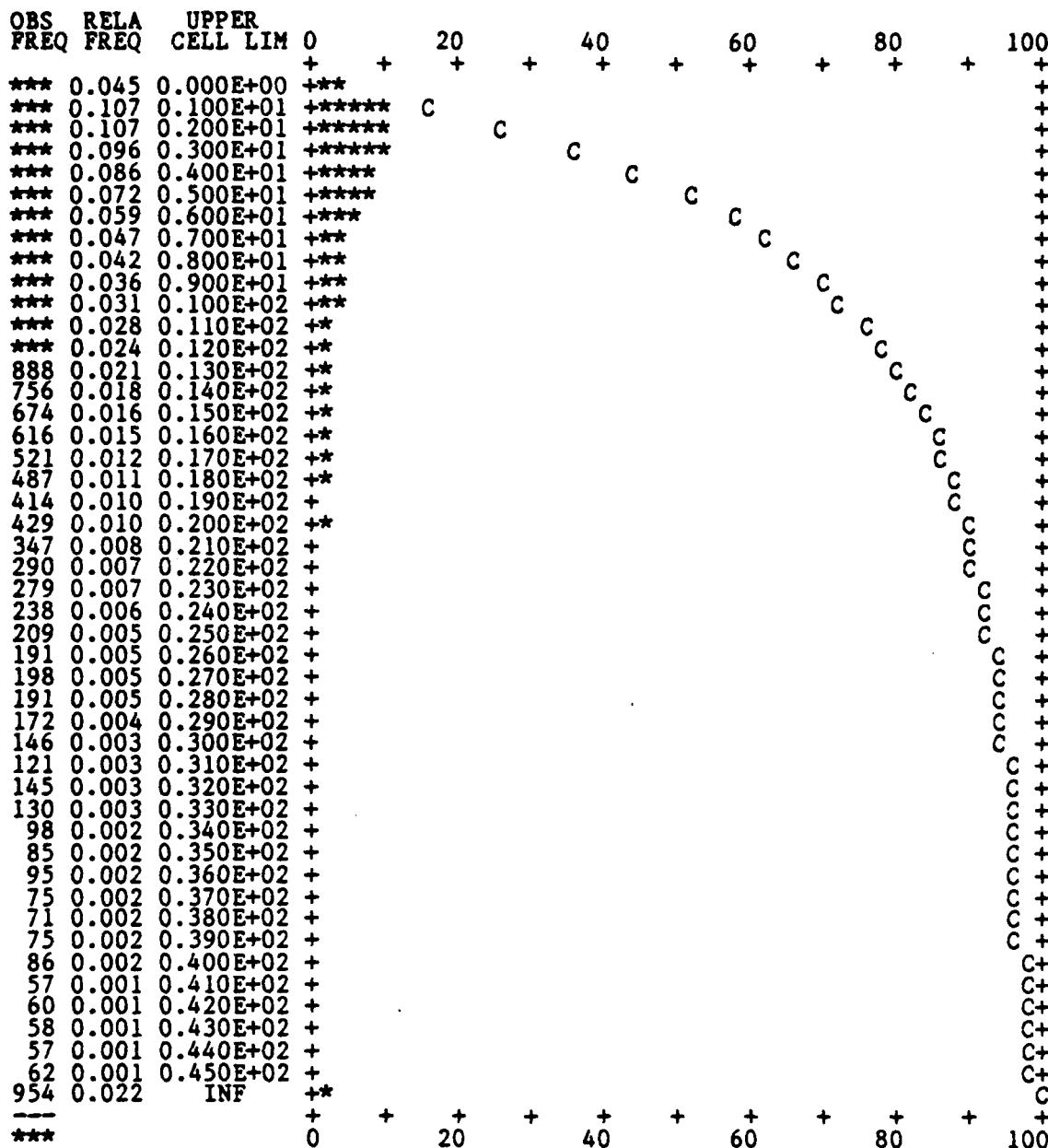
\*\*HISTOGRAM NUMBER 2\*\*  
 LEAD TIME WEEKS

OBS	RELA	UPPER	FREQ	CELL LIM 0	20	40	60	80	100
				+	+	+	+	+	+
***	0.499	0.600E+01	0.600E+01	*****	*****	*****	*****	*****	*****
***	0.297	0.130E+02	0.130E+02	*****				C	+
***	0.110	0.200E+02	0.200E+02	*****				C	+
***	0.045	0.270E+02	0.270E+02	***				C	+
***	0.022	0.340E+02	0.340E+02	**				C	+
510	0.011	0.410E+02	0.410E+02	**				C	+
307	0.007	0.480E+02	0.480E+02	+				C	+
157	0.003	0.550E+02	0.550E+02	+				C	+
103	0.002	0.620E+02	0.620E+02	+				C	+
54	0.001	0.690E+02	0.690E+02	+				C	+
95	0.002	INF	INF	+				C	+
---				+	+	+	+	+	+
***		0	0	20	40	60	80	100	

\*\*STATISTICS FOR VARIABLES BASED ON OBSERVATION\*\*

MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
LEAD TIME WEEKS 0.936E+01	0.928E+01	0.992E+00	0.000E+00	0.900E+02	****

\*\*HISTOGRAM NUMBER 3\*\*  
STAY TIME



\*\*STATISTICS FOR VARIABLES BASED ON OBSERVATION\*\*

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO. OF OBS
STAY TIME	0.935E+01	0.128E+02	0.137E+01	0.000E+00	0.180E+03	****

\*\*HISTOGRAM NUMBER 4\*\*  
STAY TIME WEEKS

OBS	RELA	UPPER	20	40	60	80	100
FREQ	FREQ	CELL LIM 0	+	+	+	+	+
***	0.572	0.600E+01	*****	*****	*****	*****	*****
***	0.230	0.130E+02	*****			C	+
***	0.092	0.200E+02	*****			C	+
***	0.041	0.270E+02	***			C	+
***	0.024	0.340E+02	**			C	+
544	0.013	0.410E+02	**			C	+
377	0.009	0.480E+02	+			C	+
234	0.006	0.550E+02	+			C	+
145	0.003	0.620E+02	+			C	+
106	0.002	0.690E+02	+			C	+
78	0.002	0.760E+02	+			C	+
53	0.001	0.830E+02	+			C	+
52	0.001	0.900E+02	+			C	+
25	0.001	0.970E+02	+			C	+
24	0.001	0.104E+03	+			C	+
97	0.002	INF	+			C	+
---			+	+	+	+	+
***		0	20	40	60	80	100

\*\*STATISTICS FOR VARIABLES BASED ON OBSERVATION\*\*

MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
STAY TIME WEEKS 0.935E+01	0.128E+02	0.137E+01	0.000E+00	0.180E+03	****

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VITA

Captain David A. Shepherd was born 28 November 1953 at Wright-Patterson AFB OH. He was raised in Marietta OH, where he graduated from high school in 1972. He entered Harding College and earned a Bachelor of Arts degree in Music Education in 1976. After teaching in Ohio for three and a half years, Captain Shepherd received his commission in 1979 through the Air Force Officer Training School. His initial assignment was to the Strategic Air Command at Malmstrom AFB MT, as a Vehicle Operations Officer and Traffic Management Officer. His last assignment was with the Military Airlift Command as Chief of the Aircraft Services Branch and Passenger Service Officer at Hellenikon AB, Athens, Greece. Captain Shepherd entered the Air Force Institute of Technology in May 1985. He has completed Squadron Officer School.

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*Mesis*

This research develops a prototype simulation model to assist in evaluating the benefits of the Contract Air Service Program. This program provides special fares for government employees traveling on official business aboard certain scheduled domestic flights. Because deregulation of the airline industry has generated a profusion of discount fares, a model is needed to evaluate the contract fares against a cross section of fares rather than full coach fares alone, as has been done in the past.

Route selection for the model was based on passenger volumes and full coach fares. All combinations of passenger volumes and fares were represented in the initial selection of routes. Only routes with low total costs and, therefore, little impact on potential savings were discarded from further consideration.

Discount fares for each route were selected to represent the entire spectrum of restrictions. The scope of government travel characteristics required for the model were identified. Parameters were established to exercise the model's ability to apply discount fares for eligible travelers.

The results of the research prove the feasibility of implementing simulation as an improved means for evaluating the effectiveness of the Contract Air Service Program. Recommendations for the development of a comprehensive model are discussed.

*Travel, Commercial transportation,  
the future mission, Government  
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D T C